PB82-261959

# Estimating Concentrations Downwind from an Instantaneous Puff Release

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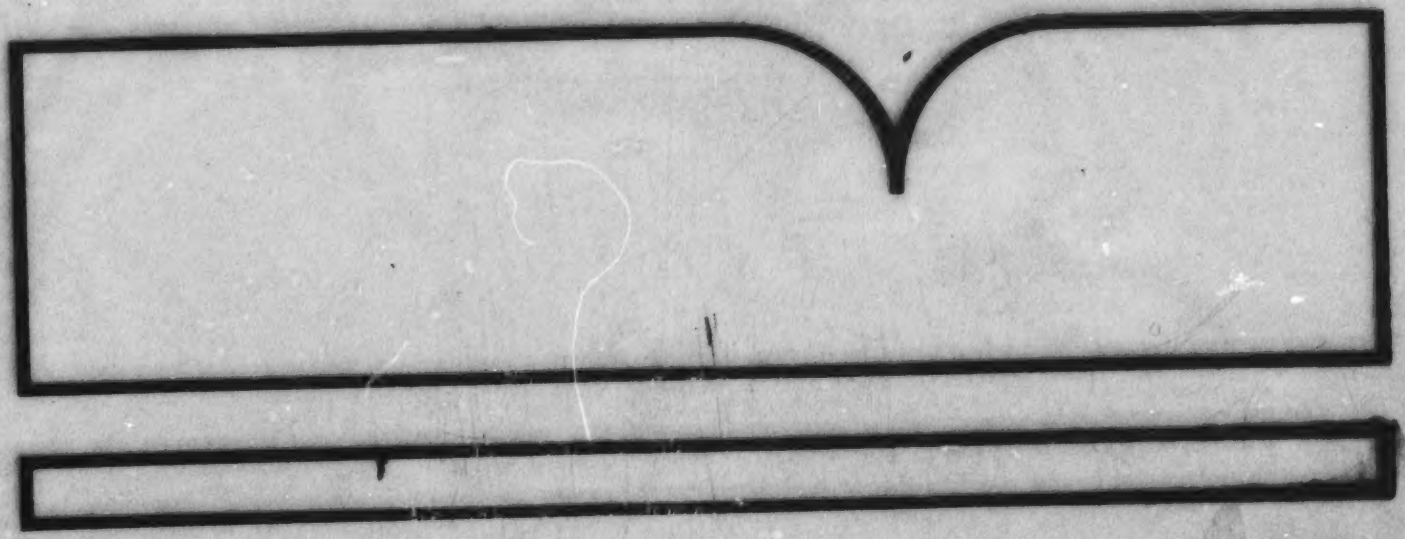
Research Triangle Park, NC

Aug 82



U.S. Department of Commerce
National Technical Information Service
NTIS

PB82-261959

EPA 600/3-82-078
August 1982

# ESTIMATING CONCENTRATIONS DOWNWIND FROM AN INSTANTANEOUS PUFF RELEASE

by

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**TECHNICAL REPORT DATA**
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| 1. REPORT NO. | 2. | 3. RECIPIENT'S ACCESSION NO. |
|---|---|---|
| EPA 600/3-82-078 | | PB82 261959 |

| 4. TITLE AND SUBTITLE | 5. REPORT DATE |
|---|---|
| ESTIMATING CONCENTRATIONS DOWNWIND FROM AN INSTANTANEOUS PUFF RELEASE | August 1982 |
| | 6. PERFORMING ORGANIZATION CODE |
| 7. AUTHOR(S) | 8. PERFORMING ORGANIZATION REPORT NO. |
| William B. Petersen | |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Environmental Sciences Research Laboratory -- RTP, NC<br>Office of Research and Development<br>U.S. Environmental Protection Agency<br>Research Triangle Park, NC 27711 | 10. PROGRAM ELEMENT NO.<br>CDTA1D/04-1315 (FY-82)<br>11. CONTRACT/GRANT NO. |
| 12. SPONSORING AGENCY NAME AND ADDRESS<br>Same as above | 13. TYPE OF REPORT AND PERIOD COVERED<br>Inhouse 6/80 - 10/81<br>14. SPONSORING AGENCY CODE<br>EPA/600/09 |

15. SUPPLEMENTARY NOTES

16. ABSTRACT

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17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
|---|---|---|
| | | |

| 18. DISTRIBUTION STATEMENT | 19. SECURITY CLASS *(This Report)* | 21. NO. OF PAGES |
|---|---|---|
| RELEASE TO PUBLIC | UNCLASSIFIED | 72 |
| | 20. SECURITY CLASS *(This page)* UNCLASSIFIED | 22. PRICE |

EPA Form 2220-1 (9-73)

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ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to the many people who reviewed and offered suggestions for improvement of this document. Also, I would like to express my appreciation to Joan Emory for assistance.

# SECTION 1
# INTRODUCTION

This document is provided in response to the need for making dispersion estimates of accidental releases of hazardous chemicals. Every year there are news stories of industrial or transportation related spills requiring the evacuation of nearby residents. The main objective of this work is to provide the air pollution specialist a methodology for estimating peak concentrations downwind of an instantaneous release.

The model estimates are appropriate for travel times where the atmosphere can be assumed to be steady state. A number of factors affect the length of time the atmosphere will remain approximately steady: season of the year, latitude, synoptic conditions and local meteorology such as sea breeze and terrain flows. During periods of transition (such as sunrise or sunset) stability, mixing height, wind profile, wind speed and wind direction are likely to change and therefore particular care should be exercised in characterizing the atmosphere during these time periods. Persistence of atmospheric stability is discussed by Budney (1977). For situations where the travel time of the puff is greater than an hour, the factors which affect the dispersion and trajectory of the puff should be incorporated in the concentration estimates.

The Gaussian instantaneous puff model is applicable for neutrally buoyant non-reactive releases. The dispersion of a small negatively buoyant release can be modeled using the puff equation provided the material mixes rapidly with the ambient air and disperses like a neutrally buoyant source.

The equations, nomograms and methodology described in this document were not designed for the fireman at the site of an accidental spill. He will not have the time nor the technical background to properly use the equations

and nomograms. The factors affecting his decision to order an evacuation will primarily be based on the size of the spill, the nature and toxicity of the substance. However, material provided in this document would be valuable to the air pollution specialist who is providing assistance to the fire department for the establishment of procedures to determine toxic corridors. The dispersion algorithms described would provide the basis for a model catered to the specific needs of the user. The computer algorithm described in Section 4 could also be adapted for on site use at a chemical plant using real time meteorology to predict downwind concentrations.

The document is composed of three major sections. The first few pages of Section 2 describe a technique for estimating peak concentrations of instantaneous puff releases as a function of atmospheric stability and downwind distance. This discussion was designed so that estimates of peak concentration could be provided to the agencies which are directly concerned with the immediate health and welfare of the public within a matter of minutes after an accidental spill. These initial estimates could be provided without the aid of a computer. The remainder of Section 2 is concerned with estimating average concentrations and exposure. Section 3 provides a discussion of a generalized Gaussian puff equation with the same assumptions and limitations of the approach described in Section 2. The equations in Section 3 are the basis for a computer model described in Section 4.

## SECTION 2

## CONCENTRATION ESTIMATES

### INSTANTANEOUS PEAK CONCENTRATIONS

The peak ground level concentration from an instantaneous surface release is given by Equation 1.

$$X_p = \frac{2Q}{(2\pi)^{3/2}\,\sigma_x\sigma_y\sigma_z} \qquad (1)$$

Where: Q is the total emission (g),
$\sigma_x$ is the downwind dispersion parameter (m),
$\sigma_y$ is the crosswind dispersion parameter (m),
$\sigma_z$ is the vertical dispersion parameter (m).

Typically it is assumed that $\sigma_x = \sigma_y$ for puff-type dispersion estimates. Nickola (1971) showed that, for ground level releases, $\sigma_x$ is greater than $\sigma_y$ in the first few hundred meters of travel, but the puffs become more symmetrical as travel distances approach 800 meters. For the purposes of this work $\sigma_x$ and $\sigma_y$ are assumed to be equal, and the dispersion in the xy plane will be indicated by $\sigma_r$. Equation 1 can then be expressed as:

$$X_p = \frac{2Q}{(2\pi)^{3/2}\,\sigma_r^2\,\sigma_z} \qquad (2)$$

Figure 1 shows peak ground level concentrations normalized by emission strength, $X_p/Q$, versus downwind distance for three stability regimes unstable, neutral, and very stable. The stability regimes can be determined from cloud cover, ceiling height and wind speed, using Turner's stability classification scheme (1970). In the absence of meteorological data at the site of release or from a nearby weather station, the stability regimes can be approximated as follows. On a clear, sunny day with light winds, use the unstable curves. During windy or cloudy conditions, use the neutral curves. On a clear night with calm or light winds, use the very stable curves. The dispersion coefficients for the three stability classes are those recommended by Slade (1968). Figure 1 was derived using Equation 2 with the dispersion coefficients mentioned above. Equation 2 is applicable only for surface releases. Solid lines on the curve represent distances of observed data. Dashed lines are extrapolations.

Example Problem 2-1

A 1000 kg instantaneous release of chlorine occurs during neutral stability conditions with a mean wind speed of 3 m/sec. What is the peak concentration 5 km downwind?

Step 1. Use Figure 1 to determine $X_p/Q$ at 5 km downwind on the neutral stability curve.

$X_p/Q = 9.5 \times 10^{-8}$ Note: $X_p/Q$ is independent of u.

Step 2. Compute $X_p = X_p/Q \times Q$

$X_p = (9.5 \times 10^{-8}) \times (1.0 \times 10^{6}) = 9.5 \times 10^{-2}$ g/m$^3$

If the atmosphere was actually very stable rather than neutral, to what downwind distance would the peak concentration be greater than that computed in Step 2?

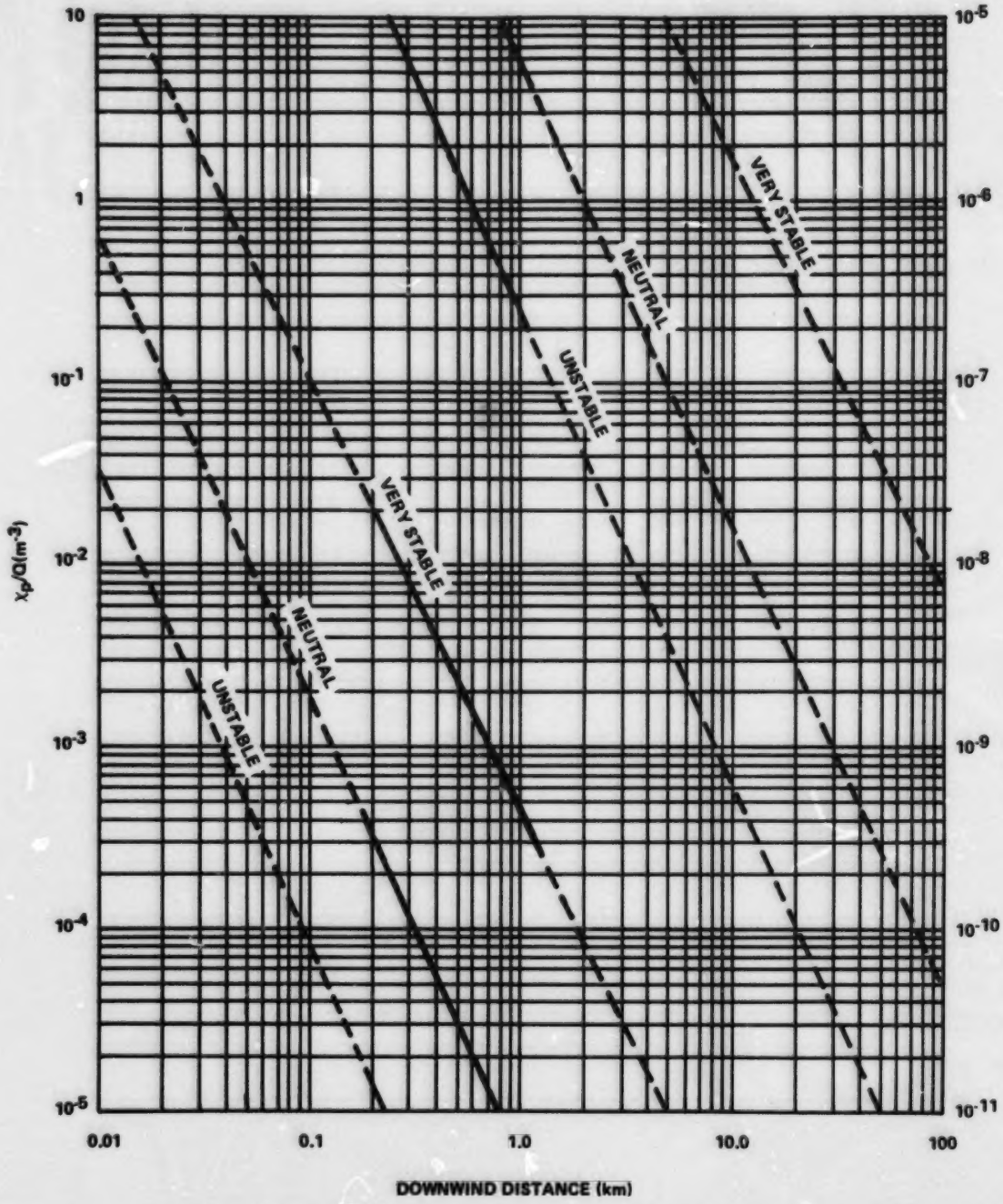


FIGURE 1. $\chi_p/Q$ VERSUS DOWNWIND DISTANCE. THE LEFT HAND SCALE IS FOR $\chi_p/Q$ VALUES OF $10^{-5}$ TO 10. THE RIGHT HAND SCALE IS FOR $\chi_p/Q$ VALUES OF $10^{-11}$ TO $10^{-6}$.

Step 1. Find $\chi/Q$ ($9.5 \times 10^{-8}$) on Figure 1, on the very stable curve.

Step 2. Read down to the distance scale.

$x$ = 32 km.

CONVERSION OF CONCENTRATION UNITS

The equation of state can be used for conversion of concentrations from $\mu g/m^3$ to ppm.

$$X(ppm) = \frac{\chi(\mu g/m^3) \times T(K) \times R}{M \times P(mb)}$$

where: T is the absolute temperature (K),

M is the gram molecular weight (gm-mole),

P is the atmospheric pressure (mb),

R is the universal gas constant $8.31 \times 10^{-2}$ $\frac{mb\ m^3}{gm\text{-}mole\ K}$.

The equation to convert ppm to $ug/m^3$ is given below.

$$X(\mu g/m^3) = \frac{X(ppm) \times M \times P(mb)}{T(K) \times 8.31 \times 10^{-2}}$$

In the example above the ambient temperature was 80°F and the atmospheric pressure was 980 mb. Find the concentration in ppm.

$$T(^oC) = 5/9(T(^oF)-32)$$

The absolute temperature is 299.7 (K). The molecular weight of chlorine ($CL_2$) is 70.91.

$$\chi_{(ppm)} = \frac{95000(\mu g/m^3) \times 299.7(K) \times 8.31 \times 10^{-2}}{70.91 \times 980(mb)} = 34 \text{ (ppm)}$$

The peak concentration 5 km downwind is 0.095 $g/m^3$ or 34 ppm.

AVERAGE CONCENTRATIONS

In the paragraphs that follow a methodology is described for computing ground level concentrations from an instantaneous surface release for a given stability class and sampling time. The average concentration over sampling time $\tau$ can be expressed as some fraction of the peak concentration.

$$\bar{\chi}_\tau = \chi_p \times F, \qquad (3)$$

where: $\chi_\tau$ is the average concentration for a given sampling time $\tau$,

$\tau$ is the sampling time, i.e. 5 min., 1-hour etc.,(expressed in seconds)

$\chi_p$ is the instantaneous peak concentration,

F is the correction factor for sampling time, which always has a value less than or equal to one.

The correction factor F can be computed as follows:

$$F = \frac{(A-0.5)}{(N)\ 0.3989}, \qquad (4)$$

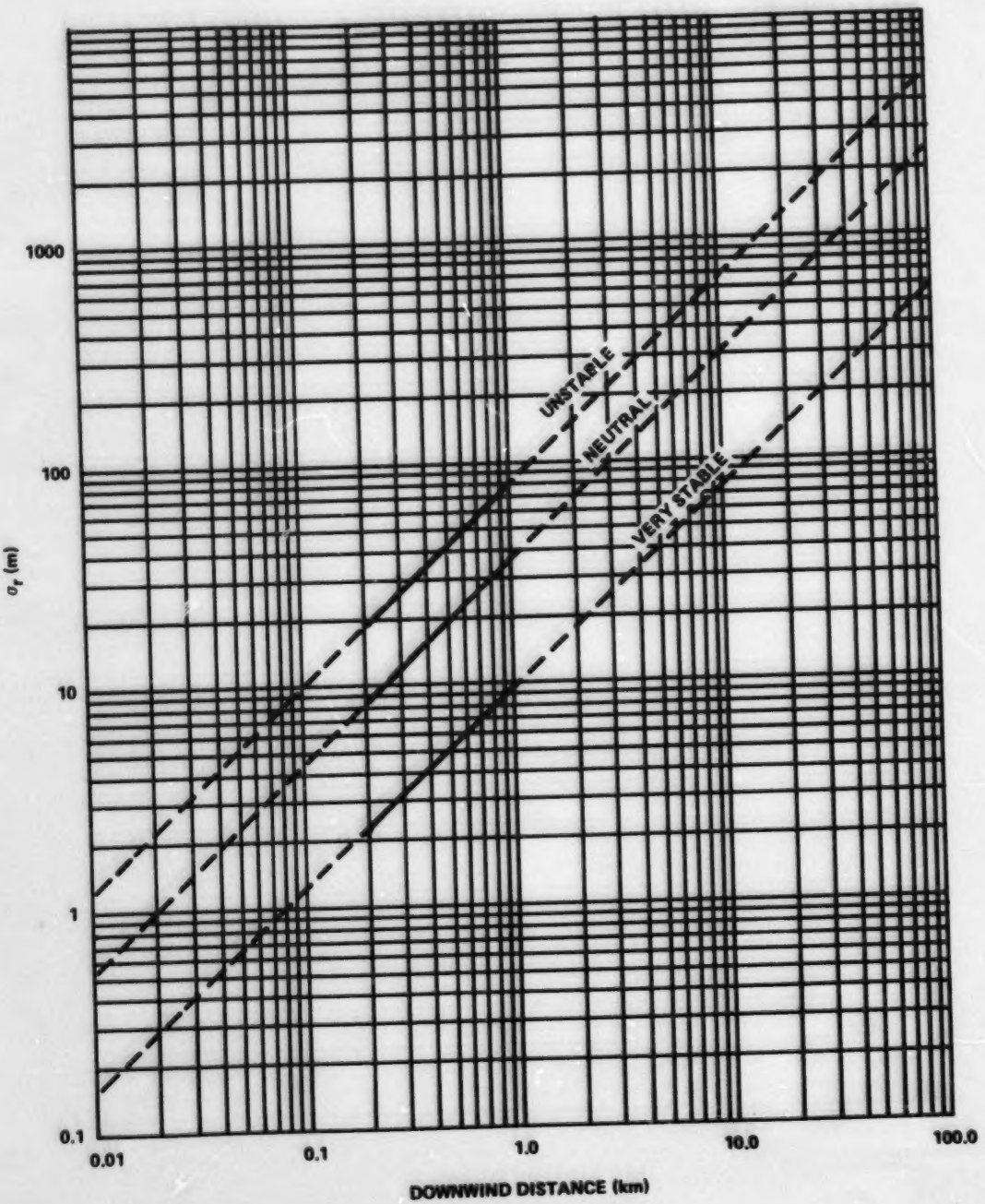


FIGURE 2. $\sigma_z$ VERSUS DOWNWIND DISTANCE

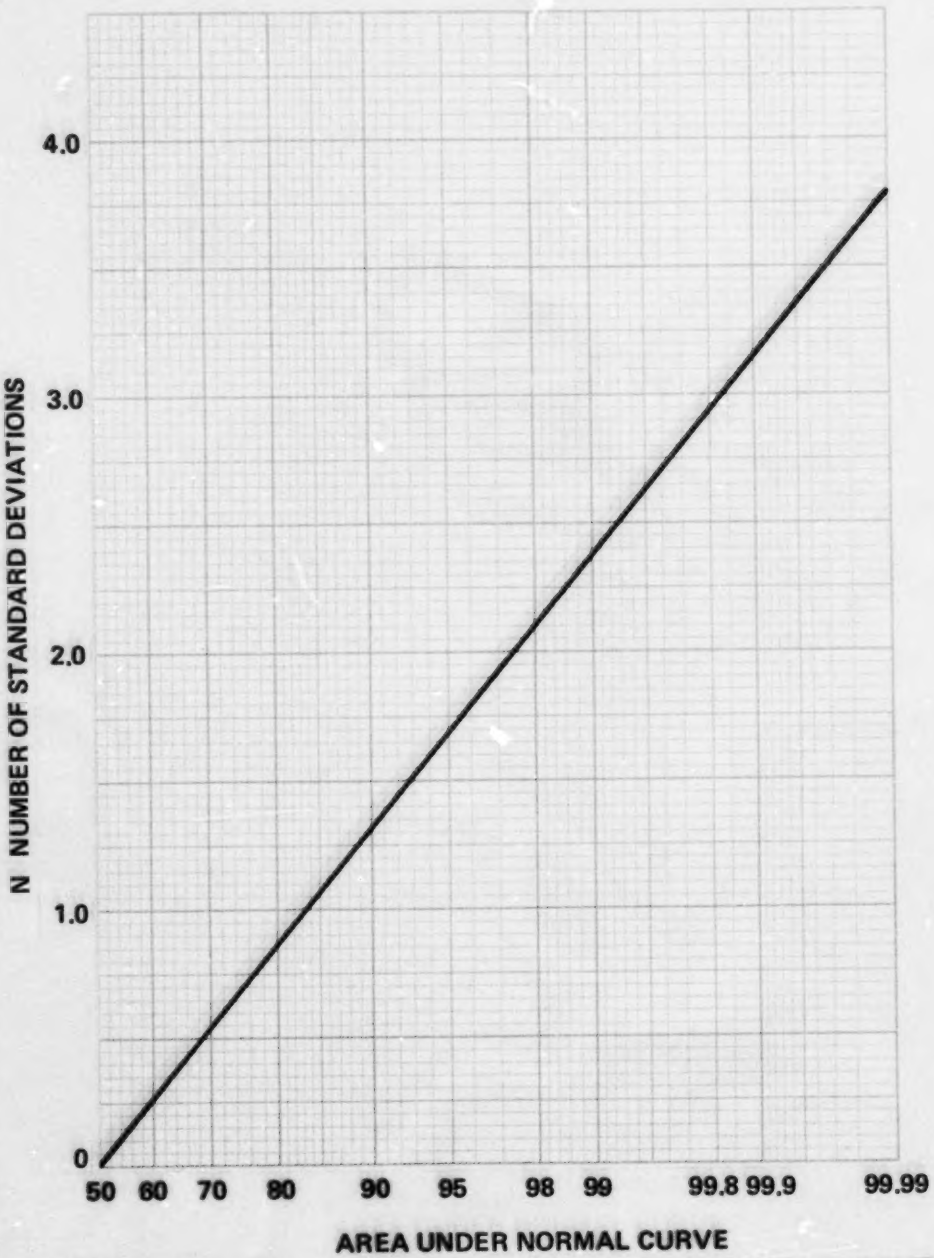


Figure 3. Percent area under normal curve for a given number of standard deviations.

where: A is the cumulative area under the normal curve (Figure 3),

N is the number of standard deviations out from the peak of the Gaussian distribution.

$$N = \frac{\tau u}{2\sigma_r},$$

u is the mean wind speed,

$\sigma_r$ is the horizontal dispersion coefficient (Figure 2).

The concentration at a given receptor location ranges from zero to a peak value as the puff moves towards the receptor. The peak instantaneoous concentration is always assumed to occur at time t when the center of the puff is at the receptor location. If the growth of the puff is small as the puff passes over the receptor, then the peak average concentration for sampling time $\tau$ at a particular location occurs during the time period $t - \tau/2$ to $t + \tau/2$.

Example Problem 2-2

For the conditions given in Example problem 2-1, find the peak 5 minute average concentration and the peak 1-hour average concentration at 5 km downwind.

Step 1. Compute the instantaneous peak concentration $\chi_p$.

From problem 2-1, $\chi_p = 9.5 \times 10^{-2}$ g/m$^3$.

Step 2. Compute A.

(a) Determine the number of standard deviations.

$$N = \frac{\tau u}{2\sigma_r} = \frac{300(3)}{(2)(150)} = 3.0$$

$\sigma_r$ is approximately 150 meters, determined from Figure 2 at 5 km downwind.

(b) Given a value of N = 3.0 determine A from Figure 3.

A = 0.998

Step 3. Compute $\chi_\tau$.

Substitute A into Equation 4.

$$F = \frac{(0.998-0.5)}{(3.0)\ 0.3989} = 0.42$$

Substitute F into Equation 3 to determine peak 5 minute average concentration.

$$\bar{\chi}_\tau = 0.42 \times 9.5\times10^{-2} = 4.0\times10^{-2}\ g/m^3.$$

In a manner analogous to the above, the peak 1-hour average concentration can be computed.

$$N = \frac{3600\ (3)}{2\ \sigma_r} = 36.$$

From Figure 3, A ≈ 1.

$$F = \frac{(1.-0.5)}{(36)\ \ 0.3989} = 0.035$$

Substitute F into Equation 3 to find the peak 1-hour average concentration.

$$\bar{\chi}_\tau = 0.035 \times 9.5\times10^{-2} = 3.3\times10^{-3}\ g/m^3.$$

The total dosage, D, at a given downwind distance, stability class, and wind speed can be approximated using the following equation.

$$D \cong \chi_p \times \frac{2.5\,\sigma_r}{u} \text{ (matter-time/volume)} \qquad (5)$$

$\sigma_r$ is determined for the given stability class and downwind distance.

## SECTION 3

## INSTANTANEOUS PUFF MODEL

The preceding section presented an approach to estimating peak ground level concentrations from instantaneous releases for a given sampling time. No mention was made of the basic assumptions inherent in the approach. Neither was there any discussion of the approach to computing concentrations out from the puff center for ground level releases or elevated releases. These topics were intentionally omitted from Section 2 for the sake of clarity and brevity. Also, it is likely that the peak concentration estimates for ground level releases are the most critical estimates in an emergency situation.

This section will present a more generalized Gaussian puff model, allowing for factors such as mixing height, cross wind concentration estimates, and elevated releases. A computerized puff model is presented in Section 4 and an example output of the model presented in Appendix A. An example problem is also presented to demonstrate the use of the model.

### PUFF EQUATIONS

The generalized puff equation is given as:

$$\chi(x, y, z, h) = \frac{Q}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z} \exp\left[-1/2\left(\frac{x-ut}{\sigma_x}\right)^2\right] \exp\left[-1/2\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-1/2\left(\frac{z+h}{\sigma_z}\right)^2\right] + \exp\left[-1/2\left(\frac{z-h}{\sigma_z}\right)^2\right]\right\}$$

Following the puff, and assuming $\sigma_x = \sigma_y$, the puff equation can be written as follows:

$$\chi_{(r,z,h)} = \frac{Q}{(2\pi)^{3/2}\,\sigma_r^2\,\sigma_z}\ \exp\left[-1/2\left(\frac{r}{\sigma_r}\right)^2\right]\left\{\exp\left[-1/2\left(\frac{z+h}{\sigma_z}\right)^2\right] + \exp\left[-1/2\left(\frac{z-h}{\sigma_z}\right)^2\right]\right\} \quad (6)$$

Equation 2 is a simplification of Equation 6 for estimating peak ground level concentrations from surface releases. The peak concentration at distances beyond the point where $\sigma_z$ is greater than 0.8L (mixing height) can be expressed as:

$$\chi(x,0,0,0) = \frac{Q}{2\pi\sigma_r^2\,L} \qquad \text{for } \sigma_z > 0.8L \quad (7)$$

The concentration at the ground from an elevated release at a radial distance r from the puff center is given by Equation 8.

$$\chi_{(x,r,o,h)} = \frac{Q}{2\pi\,\sigma_r^2\,L}\ \exp\left[-1/2\left(\frac{r}{\sigma_r}\right)^2\right] \quad \text{for } \sigma_z > 0.8L \quad (8)$$

Equations 7 and 8 account for reflection from the top of the mixed depth layer and are appropriate for surface level releases during netural and unstable conditons. However, if the effective release height is small compared to the mixing height, Equations 7 and 8 are still good approximations.

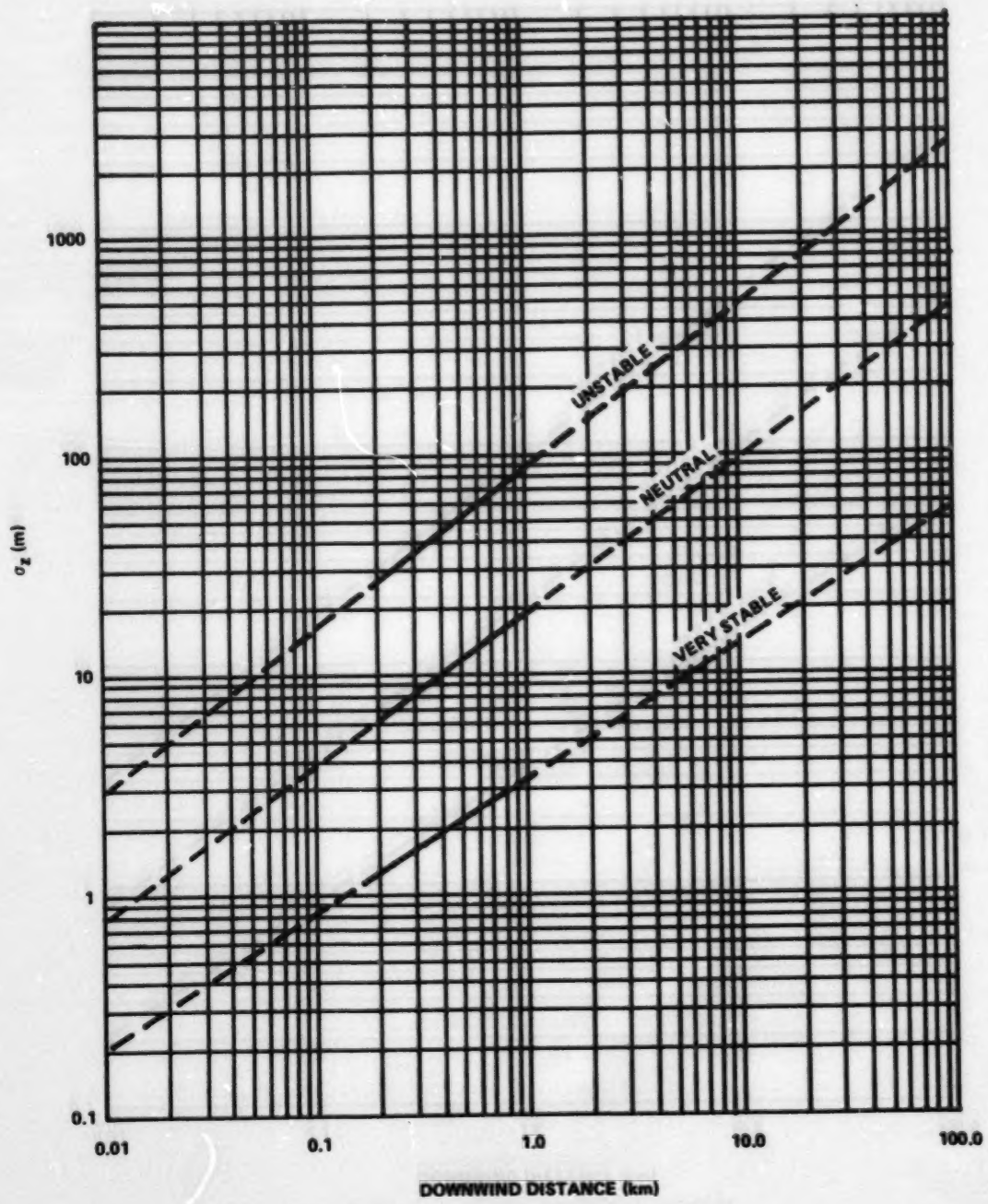


FIGURE 4. $\sigma_z$ VERSUS DOWNWIND DISTANCE

Frequently, instantaneous releases are large enough in the horizontal and vertical dimensions that the initial size cannot be ignored in the concentration estimates. One approach to assessing the impact of the initial size on downwind concentrations is to introduce an initial horizontal dispersion parameter, $\sigma_{r_o}$, and an initial vertical dispersion parameter, $\sigma_{z_o}$. $\sigma_{r_o}$ can be approximated by dividing the total initial width (W) of the puff by 4.3, $\sigma_{r_o} = W/4.3$. $\sigma_{z_o}$ can be approximated by dividing the initial vertical extent of the puff (h) by 2.15, $\sigma_{z_o} = h/2.15$. The total horizontal and vertical dispersion parameters are then given by:

$$\sigma_{r_t} = (\sigma_r^2 + \sigma_{r_o}^2)^{1/2}, \tag{9}$$

$$\sigma_{z_t} = (\sigma_z^2 + \sigma^2_{z_o})^{1/2}. \tag{10}$$

$\sigma_r$ and $\sigma_z$ are obtained from Figures 2 and 4 for the specified stability and downwind distance.

Example Problem 3-1

A nuclear power reactor has a sudden radioactive release of $1.5 \times 10^4$ curies at 2 in the afternoon. The reactor building is hemispherically shaped with a radius of 20 meters. The existing meteorological conditions are unstable with a 1500 m mixing height and a 3 m/sec wind. From the weather forecast, it is anticipated that the puff will pass over or near a receptor 10 km downwind.

(A) What is the peak concentration 10 km downwind?

If the puff release is about the same size as the reactor building then $\sigma_{z_o} = 20/2.15 = 9.3$ m, and $\sigma_{y_o} = 40/4.3 = 9.3$ m. From Figures 2 and 4, $\sigma_r$ and $\sigma_z$ are 670 m and 440 m, respectively. Using Equations 9 and 10, $\sigma_{r_t} = 670.1$ and $\sigma_{z_t} = 440.1$. Since 440.1 is less than 0.8 times the mixing height, $\chi_p$ can be determined from Equation 2, or Figure 1.

$$\chi_p = 9.6 \times 10^{-6} \text{ curies/m}^3.$$

(B) At 10 km downwind, what is the radial dimension of the puff where the concentration drops to 0.1 $\chi_p$? What area does the puff cover?

For a surface concentration estimate, Equation 6 reduces to

$$\chi = \frac{Q}{(2\pi)^{3/2}\,\sigma_r^{\,2}\,\sigma_z}\ \exp\left[-1/2\left(\frac{r}{\sigma_r}\right)^2\right] \quad \text{or} \quad \chi = \chi_p\ \exp\left[-1/2\left(\frac{r}{\sigma_r}\right)^2\right]$$

$$\text{If } \chi/\chi_p = 0.1 \text{ then } 0.1 = \exp\left[-1/2\left(\frac{r}{\sigma_r}\right)^2\right]$$

The expression above can now be solved for r. $\sigma_r$ at 10 km dowwind is 670 m.

$$r = \sigma_r \times 2.15 = 1440.5 \text{ m.}$$

The radial dimension of the puff 10 km downwind is ~ 1440 m.

The area covered by the puff at this distance is = $\pi r^2$ = 6.5 $km^2$.

(C) What is the total dosage 10 km downwind, where the puff center passes?

Using the unstable curve 10 km downwind on Figure 2, $\sigma_r \cong 670$ m. Equation 5 can be used to compute the total dosage.

$$D = 9.6\times10^{-6} \times 2.5 \times \frac{670}{3} \cong 5.4\times10^{-3} \text{ curie-sec/m}^3.$$

(D) If the puff center passes 1 km from a receptor, what is the estimated dosage at the receptor?

For off-center computations of dosages, a more generalized form of the dosage equation can be used.

$$D = \frac{Q}{\pi \sigma_r \sigma_z u} \exp\left[-\left(\frac{r^2}{2\sigma_r^2} + \frac{h^2}{2\sigma_z^2}\right)\right]$$

$$D = \frac{1.5 \times 10^4}{3.1415\ (670)\ (440)\ 3} \exp\left[-\frac{1}{2}\left(\frac{1000}{670}\right)^2\right]$$

$$D = 1.8 \times 10^{-3} \text{ curie-sec/m}^3.$$

STABILITY PARAMETERS

As mentioned before, the stability parameters used in the instantaneous puff model are those recommended in Meteorology and Atomic Energy (1968). Slade classified the data according to the broad categories of unstable, neutral, and very stable. A review of the data reveals two pertinent points: (1) There was very little data upon which to base the $\sigma_z$'s during unstable conditions. (2) Much of the dispersion data during stable conditions lie closer to the Pasquill-Gifford F curve than to the curve recommended by Slade.

A plot of $\sigma_z$ versus downwind distance is shown in Figure 4. The figure was not presented in Section 2 because it was not directly needed for the analysis presented. The vertical dispersion parameters are embodied in the $\chi/Q$ values in Figure 1. Figure 1 could, of course, be developed for any set of dispersion parameters appropriate for a given release. Appendix C lists the changes that would be required to change the dispersion parameters in the code of the puff model.

## MODEL APPLICABILITY

Estimating concentrations at point locations are very difficult because of the deficiencies in determining the trajectory of the puff. Puff trajectory is most important if concentration estimates are to be made at specific points. However, the modeling effort is significantly simplified if the magnitudes of the concentrations are needed without regard to exactly where the concentrations will occur. Releases are seldom point sources, but are more typically small area sources. Small area source releases can be modeled to some extent by using initial dispersion parameters. The initial horizontal dispersion is typically calculated by dividing the initial horizontal dimension of the area source by 4.3. This method will give reasonable concentration estimates at downwind distances greater than about 5 times the horizontal dimension of the source. As with the lateral dispersion, the initial vertical dispersion parameter is typically evaluated by dividing the initial vertical extent of the surface release by 2.15.

No model description would be complete without some guidance concerning areas of applicability. Many sources are not truly instantaneous. However, if the travel time is long compared to the release time then the puff model can be used to estimate concentrations. If the travel time to a receptor is on the same order or smaller than the release time, the Gaussian plume model can be used (see Turner, (1970). For the case where the release time is finite but smaller than the travel time, the instantaneous puff model will provide a worst-case estimate of peak concentrations for the same total release. It is difficult to evaluate the effect on average concentrations over a given sampling time for a finite release using simple models, since the puff is distorted in the downwind direction. Finally, I would like to reiterate that the modeling procedures outlined in the document are simple approaches to very complex problems. In general these techniques will yield worst case concentration estimates. The proper modeling of any sudden release requires the skills of an air quality specialist and a thorough understanding of the physical and chemical properties of the release.

## SECTION 4
## COMPUTER ALGORITHM

The FORTRAN computer program consists of a main program and three subroutines. Figure 5 depicts the general flow of the model. The main program reads all input data and produces all output. The dispersion equations given in Sections 2 and 3 are solved in the main routine as well. Subroutine DBTMX computes the distance to maximum concentration for an elevated release. Subroutine PUFSIG is called by the main program for sigma y and z values. Subroutine AVCOR computes the area under the normal curve used in the computation of average concentration estimates.

### INPUT DATA

The main routine reads control information to determine output modes and a control to read new data or modify previous data. A source data card is then required giving information on source characteristics. A meteorology card is then required followed by cards specifying locations where concentration estimates are to be made. A description of each input card type is provided in Table 1. The last card of the data set (card type 6) is used only if IOUT3 on card type 2 is equal to 1. This sequence of input data cards is shown in Figure 6. All input data are in free format which is easy to use but care should be exercised to make sure each variable is given a value in the correct order. Each variable must be separated by a comma. A brief description of each input parameter is given in Table 1 with appropriate units. The metric system of units is used throughout the puff model.

TABLE 1. DESCRIPTION OF INPUT DATA

| | | |
|---|---|---|
| Card type 1 | KTL | |
| KTL | Input data control<br>KTL=1 New problem, read all input data<br>KTL=2 Change options only, use previous data<br>KTL=3 Change options and source data<br>KTL=4 Change options and meteorological data<br>KTL=5 Change options and locations of concentration estimates<br>KTL=6 Change options and meteorological data, and locations of concentration estimates<br>KTL>100 STOP | |
| Card type 2 | IOUT1,IOUT2,IOUT3 | |
| IOUT1 | If IOUT1=1 a table of peak concentrations for different stability classes, sampling times and downwind distances is printed out | |
| IOUT2 | If IOUT2=1 concentration estimates are printed for the given input data only | |
| IOUT3 | If IOUT3=1 A critical concentration must be input. The program will compute distance to critical concentration | |
| Card type 3 | Q,H,SYOP,SZOP | |
| Q | Source strength | (g) |
| H | Effective source height | (m) |
| SYOP | Initial $\sigma_r$ | (m) |
| SZOP | Initial $\sigma_z$ | (m) |
| Card type 4 | u,HL,AVT,KST | |
| u | Wind speed | (m/sec) |
| HL | mixing height | (m) |
| AVT | Sampling time for concentration estimates | (sec) |
| KST | Stability class 1-3 | |
| Card type 5 | NREC,XR,RR,ZR | |

TABLE 1 (Continued)

| | | |
|---|---|---|
| NREC | Number of locations for which concentration estimates are to be made | |
| XR | Distance downwind from release point | (km) |
| RR | Radial distance from puff center | (m) |
| ZR | Height above ground | (m) |
| Card type 6 | XCHI | |
| XCHI | If IOUT3=1 read XCHI, critical concentration | ($g/m^3$) |

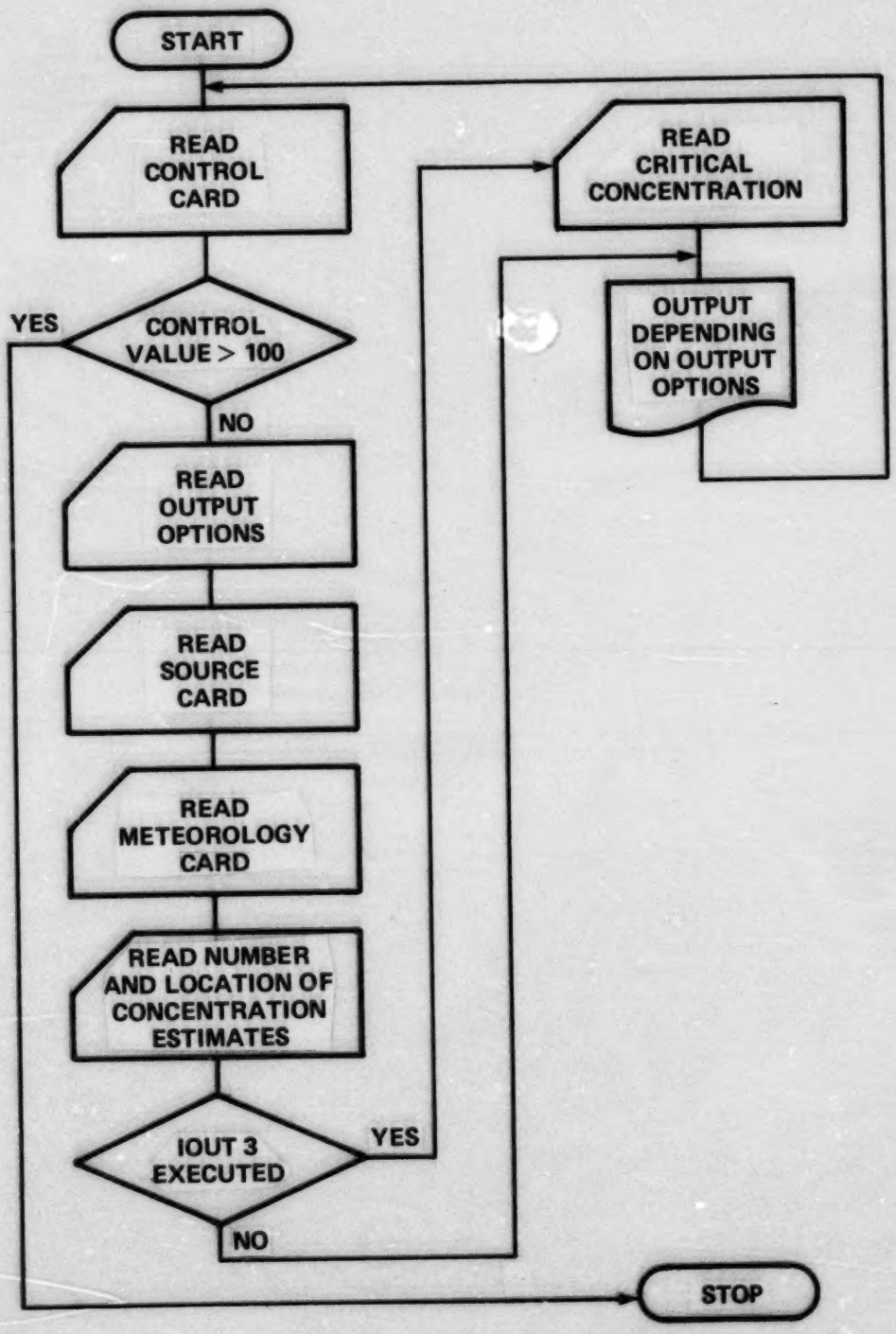


Figure 5. General flow diagram for instantaneous puff model.

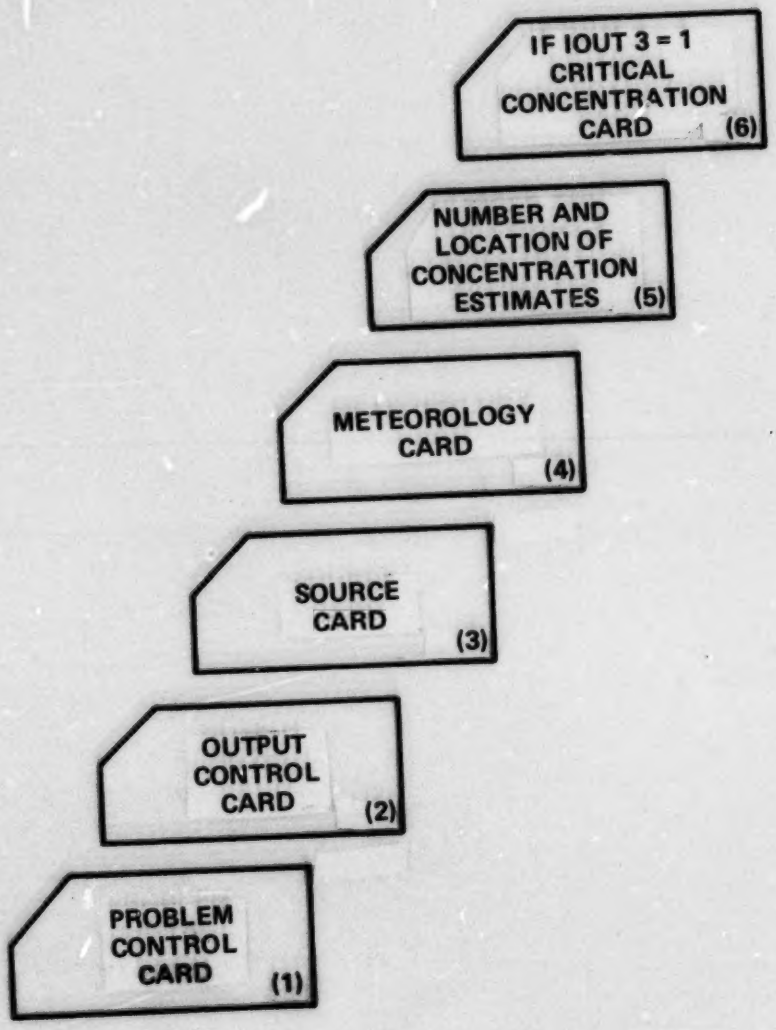


Figure 6. Input data deck for instantaneous puff model. Card type numbers are in parenthesis.

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## APPENDIX A
## EXECUTION OF INSTANTANEOUS PUFF MODEL

An example problem is provided to demonstrate the use of the instantaneous puff model. Example problems 2-1 and 2-2 are used as input into the model. Also, a puff is modeled whose effective height of release is 50 m. Table A-1 shows the input data cards for these examples. The numbers in the left hand column of the table are the card type numbers. For a description of each card type see Table 1.

Table A-2 presents the output of the model for these examples. The first ten pages of Table A-2 are a result of exercising option 1 on card type 2. This part of the output lists peak concentrations for a variety of mixing heights, stabilities, wind speeds, sampling times, and downwind distances. While these listings are helpful in assessing the impact of a puff release, they are optional and can be deleted from the output by assigning a value other than 1 to IOUT1 on card type 2. The first part of the output for all of the options is a listing of the input data.

Most of the input data and the output of the instantaneous puff model is straightforward. However, a brief discussion on a few points about the model should be profitable. The variable AVT (sampling time) on card type 4 must be assigned a value greater than zero. For peak concentration estimates, a value of 1-second for AVT is a sufficiently short time to give a good estimate of the peak. If option 3 (IOUT3) on card type 2 is utilized, the model will predict the distance to the critical concentration specified on card type 6. When using option 3 for an elevated release, the model will also give the maximum concentration and the distance to the maximum concentration. You have probably already asked yourself the question for an elevated release, which distance does the distance to critical concentration refer to, since the

critical concentration can occur at two distinct downwind distances? The distance to critical concentration is always greater than or equal to the distance to maximum concentration, thus assuring that the critical concentration will not be predicted beyond the estimated distance to critical concentration.

TABLE A-1. INPUT DATA FOR EXAMPLE PROBLEMS

| CARD TYPE | |
|---|---|
| 1 | 1 |
| 2 | 1,1,0 |
| 3 | 1000000.,0.,0.,0. |
| 4 | 3.,1500.,1.,2 |
| 5 | 1,5.,0.,0. |
| 1 | 4 |
| 2 | 0,1,0 |
| 4 | 3.,1500.,300.,2 |
| 1 | 4 |
| 2 | 0,1,0 |
| 4 | 3.,1500.,3600.,2 |
| 1 | 1 |
| 2 | 0,1,1 |
| 3 | 1000000.,50.,0.,0. |
| 4 | 3.,1500.,300.,2 |
| 5 | 3,1.,0.,0.,3.,0.,0.,5.0.,0. |
| 6 | 0.0001 |
| 1 | 999 |

## TABLE A-2 COMPUTER MODEL OUTPUT

OPTION 1 YES
OPTION 2 YES
OPTION 3 NO

SOURCE INFORMATION

| | |
|---|---|
| SOURCE STRENGTH (Q) | 1000000.0 |
| SOURCE HEIGHT (M) | .0 |
| INITIAL SIGMA R (M) | .0 |
| INITIAL SIGMA Z (M) | .0 |

METEOROLOGICAL DATA

| | |
|---|---|
| WIND SPEED (M/SEC) | 3.0 |
| MIXING HEIGHT (M) | 1500.0 |
| SAMPLING TIME (SEC) | 1.0 |
| STABILITY CLASS | 2 |

RECEPTOR DATA

| LOCATION NUMBER | DOWNWIND DISTANCE (KM) | RADIAL DISTANCE (M) | HEIGHT ABOVE GROUND (M) |
|---|---|---|---|
| 1 | 5.000 | .00 | .00 |

MIXING HEIGHT (M) 500.

| STAB. CLAS | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 1 | 3.290+04 | 1.954+03 | 5.259+02 | 2.215+02 | 8.856+01 | 1.415+00 | 2.384-01 | 1.416-02 | 3.810-03 | 1.604-03 | 7.089-04 | 9.391-05 |
| 2 | 6.782+05 | 4.164+04 | 1.138+04 | 4.840+03 | 1.956+03 | 3.281+01 | 5.641+00 | 3.463-01 | 9.462-02 | 4.025-02 | 1.627-02 | 9.988-04 |
| 3 | 2.587+07 | 1.872+06 | 5.523+05 | 2.471+05 | 1.054+05 | 2.250+03 | 4.293+02 | 3.107+01 | 9.166+00 | 4.102+00 | 1.749+00 | 1.266-01 |

MIXING HEIGHT (M) 1000.

| STAB. CLAS | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |

## TABLE A-2 (Continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.290+04 | 1.954+03 | 5.259+02 | 2.215+02 | 8.856+01 | 1.415+00 | 2.384-01 | 1.416-02 | 3.810-03 | 1.604-03 | 6.415-04 | 4.695-05 |
| 2 | 6.782+05 | 4.164+04 | 1.138+04 | 4.840+03 | 1.956+03 | 3.281+01 | 5.641+00 | 3.463-01 | 9.462-02 | 4.025-02 | 1.627-02 | 9.988-04 |
| 3 | 2.587+07 | 1.872+06 | 5.523+05 | 2.471+05 | 1.054+05 | 2.250+03 | 4.293+02 | 3.107+01 | 9.166+00 | 4.102+00 | 1.749+00 | 1.266-01 |

MIXING HEIGHT (M) 2000.

| STAB. CLAS | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 1 | 3.290+04 | 1.954+03 | 5.259+02 | 2.215+02 | 8.856+01 | 1.415+00 | 2.384-01 | 1.416-02 | 3.810-03 | 1.604-03 | 6.415-04 | 3.811-05 |
| 2 | 6.782+05 | 4.164+04 | 1.138+04 | 4.840+03 | 1.956+03 | 3.281+01 | 5.641+00 | 3.463-01 | 9.462-02 | 4.025-02 | 1.627-02 | 9.988-04 |
| 3 | 2.587+07 | 1.872+06 | 5.523+05 | 2.471+05 | 1.054+05 | 2.250+03 | 4.293+02 | 3.107+01 | 9.166+00 | 4.102+00 | 1.749+00 | 1.266-01 |

MIXING HEIGHT (M) 4000.

| STAB. CLAS | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 1 | 3.290+04 | 1.954+03 | 5.259+02 | 2.215+02 | 8.856+01 | 1.415+00 | 2.384-01 | 1.416-02 | 3.810-03 | 1.604-03 | 6.415-04 | 3.811-05 |
| 2 | 6.782+05 | 4.164+04 | 1.138+04 | 4.840+03 | 1.956+03 | 3.281+01 | 5.641+00 | 3.463-01 | 9.462-02 | 4.025-02 | 1.627-02 | 9.988-04 |
| 3 | 2.587+07 | 1.872+06 | 5.523+05 | 2.471+05 | 1.054+05 | 2.250+03 | 4.293+02 | 3.107+01 | 9.166+00 | 4.102+00 | 1.749+00 | 1.266-01 |

MIXING HEIGHT (M) 500.
STABILITY CLASS 1
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.601+03 | 2.612+02 | 1.125+02 | 6.455+01 | 3.576+01 | 1.307+00 | 2.330-01 | 1.412-02 | 3.805-03 | 1.603-03 | 7.087-04 | 9.390-05 |
| 300. | 3.201+02 | 5.225+01 | 2.249+01 | 1.291+01 | 7.167+00 | 5.033-01 | 1.504-01 | 1.315-02 | 3.699-03 | 1.579-03 | 7.030-04 | 9.380-05 |
| 900. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 6.590-04 | 9.298-05 |
| 3600. | 2.668+01 | 4.354+00 | 1.874+00 | 1.076+00 | 5.972-01 | 4.196-02 | 1.337-02 | 2.182-03 | 9.394-04 | 5.391-04 | 3.284-04 | 8.087-05 |
| 10800. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 1.103-04 | 3.999-05 |

MIXING HEIGHT (M) 500.
STABILITY CLASS 1

TABLE A-2 (Continued)

WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 5.335+02 | 8.708+01 | 3.749+01 | 2.152+01 | 1.194+01 | 8.102-01 | 1.968-01 | 1.378-02 | 3.769-03 | 1.595-03 | 7.068-04 | 9.387-05 |
| 300. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 6.590-04 | 9.298-05 |
| 900. | 3.557+01 | 5.805+00 | 2.499+00 | 1.434+00 | 7.963-01 | 5.595-02 | 1.783-02 | 2.910-03 | 1.252-03 | 7.152-04 | 4.216-04 | 8.613-05 |
| 3600. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 1.103-04 | 3.999-05 |
| 10800. | 2.964+00 | 4.838-01 | 2.083-01 | 1.195-01 | 6.636-02 | 4.662-03 | 1.486-03 | 2.425-04 | 1.044-04 | 5.991-05 | 3.675-05 | 1.338-05 |

MIXING HEIGHT (M) 500.
STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 4.713+03 | 7.951+02 | 3.475+02 | 2.015+02 | 1.131+02 | 8.337+00 | 2.687+00 | 3.007-01 | 8.936-02 | 3.902-02 | 1.601-02 | 9.966-04 |
| 300. | 9.427+02 | 1.590+02 | 6.951+01 | 4.030+01 | 2.261+01 | 1.667+00 | 5.425-01 | 9.150-02 | 3.988-02 | 2.250-02 | 1.149-02 | 9.472-04 |
| 900. | 3.142+02 | 5.300+01 | 2.317+01 | 1.343+01 | 7.538+00 | 5.558-01 | 1.808-01 | 3.050-02 | 1.333-02 | 7.730-03 | 4.338-03 | 6.679-04 |
| 3600. | 7.856+01 | 1.325+01 | 5.792+00 | 3.358+00 | 1.884+00 | 1.389-01 | 4.520-02 | 7.625-03 | 3.333-03 | 1.933-03 | 1.084-03 | 1.829-04 |
| 10800. | 2.619+01 | 4.417+00 | 1.931+00 | 1.119+00 | 6.282-01 | 4.632-02 | 1.507-02 | 2.542-03 | 1.111-03 | 6.442-04 | 3.615-04 | 6.097-05 |

MIXING HEIGHT (M) 500.
STABILITY CLASS 2
WIND SPEED (M/SEC) 10.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.414+03 | 2.385+02 | 1.043+02 | 6.045+01 | 3.392+01 | 2.501+00 | 8.137-01 | 1.370-01 | 5.711-02 | 2.967-02 | 1.374-02 | 9.752-04 |
| 300. | 2.828+02 | 4.770+01 | 2.085+01 | 1.209+01 | 6.784+00 | 5.002-01 | 1.627-01 | 2.745-02 | 1.200-02 | 6.957-03 | 3.904-03 | 6.208-04 |
| 900. | 9.427+01 | 1.590+01 | 6.951+00 | 4.030+00 | 2.261+00 | 1.667-01 | 5.425-02 | 9.150-03 | 4.000-03 | 2.319-03 | 1.301-03 | 2.195-04 |
| 3600. | 2.357+01 | 3.975+00 | 1.738+00 | 1.008+00 | 5.653-01 | 4.168-02 | 1.356-02 | 2.288-03 | 9.999-04 | 5.798-04 | 3.253-04 | 5.487-05 |
| 10800. | 7.856+00 | 1.325+00 | 5.792-01 | 3.358-01 | 1.884-01 | 1.389-02 | 4.520-03 | 7.625-04 | 3.333-04 | 1.933-04 | 1.084-04 | 1.829-05 |

MIXING HEIGHT (M) 500.
STABILITY CLASS 3
WIND SPEED (M/SEC) 1.0

| SMP. | DOWNWIND DISTANCE (KM) |
|---|---|

## TABLE A-2 (Continued)

| TIME (SEC) | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 1.678+05 | 3.229+04 | 1.501+04 | 9.058+03 | 5.305+03 | 4.745+02 | 1.675+02 | 2.493+01 | 8.344+00 | 3.892+00 | 1.700+00 | 1.261-01 |
| 300. | 3.355+04 | 6.457+03 | 3.001+03 | 1.812+03 | 1.061+03 | 9.490+01 | 3.355+01 | 6.457+00 | 3.001+00 | 1.803+00 | 1.020+00 | 1.149-01 |
| 900. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 3600. | 2.796+03 | 5.381+02 | 2.501+02 | 1.510+02 | 8.842+01 | 7.908+00 | 2.796+00 | 5.381-01 | 2.501-01 | 1.510-01 | 8.842-02 | 1.702-02 |
| 10800. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |

MIXING HEIGHT (M) 500.
STABILITY CLASS 3
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 5.592+04 | 1.076+04 | 5.002+03 | 3.019+03 | 1.768+03 | 1.582+02 | 5.592+01 | 1.076+01 | 4.894+00 | 2.752+00 | 1.388+00 | 1.222-01 |
| 300. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 900. | 3.728+03 | 7.175+02 | 3.335+02 | 2.013+02 | 1.179+02 | 1.054+01 | 3.728+00 | 7.175-01 | 3.335-01 | 2.013-01 | 1.179-01 | 2.269-02 |
| 3600. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |
| 10800. | 3.107+02 | 5.979+01 | 2.779+01 | 1.677+01 | 9.824+00 | 8.787-01 | 3.107-01 | 5.979-02 | 2.779-02 | 1.677-02 | 9.824-03 | 1.891-03 |

MIXING HEIGHT (M) 1000.
STABILITY CLASS 1
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 1.601+03 | 2.612+02 | 1.125+02 | 6.455+01 | 3.576+01 | 1.307+00 | 2.330-01 | 1.412-02 | 3.805-03 | 1.603-03 | 6.413-04 | 4.695-05 |
| 300. | 3.201+02 | 5.225+01 | 2.249+01 | 1.291+01 | 7.167+00 | 5.033-01 | 1.504-01 | 1.315-02 | 3.699-03 | 1.579-03 | 6.362-04 | 4.690-05 |
| 900. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 5.964-04 | 4.649-05 |
| 3600. | 2.668+01 | 4.354+00 | 1.874+00 | 1.076+00 | 5.972-01 | 4.196-02 | 1.337-02 | 2.182-03 | 9.394-04 | 5.391-04 | 2.972-04 | 4.043-05 |
| 10800. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 9.978-05 | 2.000-05 |

MIXING HEIGHT (M) 1000.
STABILITY CLASS 1
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

TABLE A-2 (Continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 5.335+02 | 8.708+01 | 3.749+01 | 2.152+01 | 1.194+01 | 8.102-01 | 1.968-01 | 1.378-02 | 3.769-03 | 1.595-03 | 6.396-04 | 4.693-05 |
| 300. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 5.964-04 | 4.649-05 |
| 900. | 3.557+01 | 5.805+00 | 2.499+00 | 1.434+00 | 7.963-01 | 5.595-02 | 1.783-02 | 2.910-03 | 1.252-03 | 7.152-04 | 3.816-04 | 4.306-05 |
| 3600. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 9.978-05 | 2.000-05 |
| 10800. | 2.964+00 | 4.838-01 | 2.083-01 | 1.195-01 | 6.636-02 | 4.662-03 | 1.486-03 | 2.425-04 | 1.044-04 | 5.991-05 | 3.326-05 | 6.688-06 |

MIXING HEIGHT (M) 1000.
STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 4.713+03 | 7.951+02 | 3.475+02 | 2.015+02 | 1.131+02 | 8.337+00 | 2.687+00 | 3.007-01 | 8.936-02 | 3.902-02 | 1.601-02 | 9.966-04 |
| 300. | 9.427+02 | 1.590+02 | 6.951+01 | 4.030+01 | 2.261+01 | 1.667+00 | 5.425-01 | 9.150-02 | 3.988-02 | 2.250-02 | 1.149-02 | 9.472-04 |
| 900. | 3.142+02 | 5.300+01 | 2.317+01 | 1.343+01 | 7.538+00 | 5.558-01 | 1.808-01 | 3.050-02 | 1.333-02 | 7.730-03 | 4.338-03 | 6.679-04 |
| 3600. | 7.856+01 | 1.325+01 | 5.792+00 | 3.358+00 | 1.884+00 | 1.389-01 | 4.520-02 | 7.625-03 | 3.333-03 | 1.933-03 | 1.084-03 | 1.829-04 |
| 10800. | 2.619+01 | 4.417+00 | 1.931+00 | 1.119+00 | 6.282-01 | 4.632-02 | 1.507-02 | 2.542-03 | 1.111-03 | 6.442-04 | 3.615-04 | 6.097-05 |

MIXING HEIGHT (M) 1000.
STABILITY CLASS 2
WIND SPEED (M/SEC) 10.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 1.414+03 | 2.385+02 | 1.043+02 | 6.045+01 | 3.392+01 | 2.501+00 | 8.137-01 | 1.370-01 | 5.711-02 | 2.967-02 | 1.374-02 | 9.752-04 |
| 300. | 2.828+02 | 4.770+01 | 2.085+01 | 1.209+01 | 6.784+00 | 5.002-01 | 1.627-01 | 2.745-02 | 1.200-02 | 6.957-03 | 3.904-03 | 6.208-04 |
| 900. | 9.427+01 | 1.590+01 | 6.951+00 | 4.030+00 | 2.261+00 | 1.667-01 | 5.425-02 | 9.150-03 | 4.000-03 | 2.319-03 | 1.301-03 | 2.195-04 |
| 3600. | 2.357+01 | 3.975+00 | 1.738+00 | 1.008+00 | 5.653-01 | 4.168-02 | 1.356-02 | 2.288-03 | 9.999-04 | 5.798-04 | 3.253-04 | 5.487-05 |
| 10800. | 7.856+00 | 1.325+00 | 5.792-01 | 3.358-01 | 1.884-01 | 1.389-02 | 4.520-03 | 7.625-04 | 3.333-04 | 1.933-04 | 1.084-04 | 1.829-05 |

MIXING HEIGHT (M) 1000.
STABILITY CLASS 3
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 1.678+05 | 3.229+04 | 1.501+04 | 9.058+03 | 5.305+03 | 4.745+02 | 1.675+02 | 2.493+01 | 8.344+00 | 3.891+00 | 1.700+00 | 1.261-01 |
| 300. | 3.355+04 | 6.457+03 | 3.001+03 | 1.812+03 | 1.061+03 | 9.490+01 | 3.355+01 | 6.457+00 | 3.001+00 | 1.803+00 | 1.020+00 | 1.149-01 |

## TABLE A-2 (Continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 900. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 3600. | 2.796+03 | 5.381+02 | 2.501+02 | 1.510+02 | 8.842+01 | 7.908+00 | 2.796+00 | 5.381-01 | 2.501-01 | 1.510-01 | 8.842-02 | 1.702-02 |
| 10800. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |

MIXING HEIGHT (M) 1000.
STABILITY CLASS 3
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 5.592+04 | 1.076+04 | 5.002+03 | 3.019+03 | 1.768+03 | 1.582+02 | 5.592+01 | 1.076+01 | 4.894+00 | 2.752+00 | 1.388+00 | 1.222-01 |
| 300. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 900. | 3.728+03 | 7.175+02 | 3.335+02 | 2.013+02 | 1.179+02 | 1.054+01 | 3.728+00 | 7.175-01 | 3.335-01 | 2.013-01 | 1.179-01 | 2.269-02 |
| 3600. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |
| 10800. | 3.107+02 | 5.979+01 | 2.779+01 | 1.677+01 | 9.824+00 | 8.787-01 | 3.107-01 | 5.979-02 | 2.779-02 | 1.677-02 | 9.824-03 | 1.891-03 |

MIXING HEIGHT (M) 2000.
STABILITY CLASS 1
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.601+03 | 2.612+02 | 1.125+02 | 6.455+01 | 3.576+01 | 1.307+00 | 2.330-01 | 1.412-02 | 3.805-03 | 1.603-03 | 6.413-04 | 3.811-05 |
| 300. | 3.201+02 | 5.225+01 | 2.249+01 | 1.291+01 | 7.167+00 | 5.033-01 | 1.504-01 | 1.315-02 | 3.699-03 | 1.579-03 | 6.362-04 | 3.807-05 |
| 900. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 5.964-04 | 3.773-05 |
| 3600. | 2.668+01 | 4.354+00 | 1.874+00 | 1.076+00 | 5.972-01 | 4.196-02 | 1.337-02 | 2.182-03 | 9.394-04 | 5.391-04 | 2.972-04 | 3.282-05 |
| 10800. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 9.978-05 | 1.623-05 |

MIXING HEIGHT (M) 2000.
STABILITY CLASS 1
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 5.335+02 | 8.708+01 | 3.749+01 | 2.152+01 | 1.194+01 | 8.102-01 | 1.968-01 | 1.378-02 | 3.769-03 | 1.595-03 | 6.396-04 | 3.809-05 |
| 300. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 5.964-04 | 3.773-05 |
| 900. | 3.557+01 | 5.805+00 | 2.499+00 | 1.434+00 | 7.963-01 | 5.595-02 | 1.783-02 | 2.910-03 | 1.252-03 | 7.152-04 | 3.816-04 | 3.495-05 |
| 3600. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 9.978-05 | 1.623-05 |
| 10800. | 2.964+00 | 4.838-01 | 2.083-01 | 1.195-01 | 6.636-02 | 4.662-03 | 1.486-03 | 2.425-04 | 1.044-04 | 5.991-05 | 3.326-05 | 5.428-06 |

TABLE A-2 (Continued)

MIXING HEIGHT (M) 2000.
STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 4.713+03 | 7.951+02 | 3.475+02 | 2.015+02 | 1.131+02 | 8.337+00 | 2.687+00 | 3.007-01 | 8.936-02 | 3.902-02 | 1.601-02 | 9.966-04 |
| 300. | 9.427+02 | 1.590+02 | 6.951+01 | 4.030+01 | 2.261+01 | 1.667+00 | 5.425-01 | 9.150-02 | 3.988-02 | 2.250-02 | 1.149-02 | 9.472-04 |
| 900. | 3.142+02 | 5.300+01 | 2.317+01 | 1.343+01 | 7.538+00 | 5.558-01 | 1.808-01 | 3.050-02 | 1.333-02 | 7.730-03 | 4.338-03 | 6.679-04 |
| 3600. | 7.856+01 | 1.325+01 | 5.792+00 | 3.358+00 | 1.884+00 | 1.389-01 | 4.520-02 | 7.625-03 | 3.333-03 | 1.933-03 | 1.084-03 | 1.829-04 |
| 10800. | 2.619+01 | 4.417+00 | 1.931+00 | 1.119+00 | 6.282-01 | 4.632-02 | 1.507-02 | 2.542-03 | 1.111-03 | 6.442-04 | 3.615-04 | 6.097-05 |

MIXING HEIGHT (M) 2000.
STABILITY CLASS 2
WIND SPEED (M/SEC) 10.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.414+03 | 2.385+02 | 1.043+02 | 6.045+01 | 3.392+01 | 2.501+00 | 8.137-01 | 1.370-01 | 5.711-02 | 2.967-02 | 1.374-02 | 9.752-04 |
| 300. | 2.828+02 | 4.770+01 | 2.085+01 | 1.209+01 | 6.784+00 | 5.002-01 | 1.627-01 | 2.745-02 | 1.200-02 | 6.957-03 | 3.904-03 | 6.208-04 |
| 900. | 9.427+01 | 1.590+01 | 6.951+00 | 4.030+00 | 2.261+00 | 1.667-01 | 5.425-02 | 9.150-03 | 4.000-03 | 2.319-03 | 1.301-03 | 2.195-04 |
| 3600. | 2.357+01 | 3.975+00 | 1.738+00 | 1.008+00 | 5.653-01 | 4.168-02 | 1.356-02 | 2.288-03 | 9.999-04 | 5.798-04 | 3.253-04 | 5.487-05 |
| 10800. | 7.856+00 | 1.325+00 | 5.792-01 | 3.358-01 | 1.884-01 | 1.389-02 | 4.520-03 | 7.625-04 | 3.333-04 | 1.933-04 | 1.084-04 | 1.829-05 |

MIXING HEIGHT (M) 2000.
STABILITY CLASS 3
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.678+05 | 3.229+04 | 1.501+04 | 9.058+03 | 5.305+03 | 4.745+02 | 1.675+02 | 2.493+01 | 8.344+00 | 3.892+00 | 1.700+00 | 1.261-01 |
| 300. | 3.355+04 | 6.457+03 | 3.001+03 | 1.812+03 | 1.061+03 | 9.490+01 | 3.355+01 | 6.457+00 | 3.001+00 | 1.803+00 | 1.020+00 | 1.149-01 |
| 900. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 3600. | 2.796+03 | 5.381+02 | 2.501+02 | 1.510+02 | 8.842+01 | 7.908+00 | 2.796+00 | 5.381-01 | 2.501-01 | 1.510-01 | 8.842-02 | 1.702-02 |
| 10800. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |

TABLE A-2 (Continued)

MIXING HEIGHT (M) 2000.
STABILITY CLASS 3
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 5.592+04 | 1.076+04 | 5.002+03 | 3.019+03 | 1.768+03 | 1.582+02 | 5.592+01 | 1.076+01 | 4.894+00 | 2.752+00 | 1.388+00 | 1.222-01 |
| 300. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 900. | 3.728+03 | 7.175+02 | 3.335+02 | 2.013+02 | 1.179+02 | 1.054+01 | 3.728+00 | 7.175-01 | 3.335-01 | 2.013-01 | 1.179-01 | 2.269-02 |
| 3600. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |
| 10800. | 3.107+02 | 5.979+01 | 2.779+01 | 1.677+01 | 9.824+00 | 8.787-01 | 3.107-01 | 5.979-02 | 2.779-02 | 1.677-02 | 9.824-03 | 1.891-03 |

MIXING HEIGHT (M) 4000.
STABILITY CLASS 1
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.601+03 | 2.612+02 | 1.125+02 | 6.455+01 | 3.576+01 | 1.307+00 | 2.330-01 | 1.412-02 | 3.805-03 | 1.603-03 | 6.413-04 | 3.811-05 |
| 300. | 3.201+02 | 5.225+01 | 2.249+01 | 1.291+01 | 7.167+00 | 5.033-01 | 1.504-01 | 1.315-02 | 3.699-03 | 1.579-03 | 6.362-04 | 3.807-05 |
| 900. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 5.964-04 | 3.773-05 |
| 3600. | 2.668+01 | 4.354+00 | 1.874+00 | 1.076+00 | 5.972-01 | 4.196-02 | 1.337-02 | 2.182-03 | 9.394-04 | 5.391-04 | 2.972-04 | 3.282-05 |
| 10800. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 9.978-05 | 1.623-05 |

MIXING HEIGHT (M) 4000.
STABILITY CLASS 1
WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 5.335+02 | 8.708+01 | 3.749+01 | 2.152+01 | 1.194+01 | 8.102-01 | 1.968-01 | 1.378-02 | 3.769-03 | 1.595-03 | 6.396-04 | 3.809-05 |
| 300. | 1.067+02 | 1.742+01 | 7.497+00 | 4.303+00 | 2.389+00 | 1.678-01 | 5.348-02 | 8.362-03 | 2.992-03 | 1.399-03 | 5.964-04 | 3.773-05 |
| 900. | 3.557+01 | 5.805+00 | 2.499+00 | 1.434+00 | 7.963-01 | 5.595-02 | 1.783-02 | 2.910-03 | 1.252-03 | 7.152-04 | 3.816-04 | 3.495-05 |
| 3600. | 8.892+00 | 1.451+00 | 6.248-01 | 3.586-01 | 1.991-01 | 1.399-02 | 4.457-03 | 7.274-04 | 3.131-04 | 1.797-04 | 9.978-05 | 1.623-05 |
| 10800. | 2.964+00 | 4.838-01 | 2.083-01 | 1.195-01 | 6.636-02 | 4.662-03 | 1.486-03 | 2.425-04 | 1.044-04 | 5.991-05 | 3.326-05 | 5.428-06 |

MIXING HEIGHT (M) 4000.
STABILITY CLASS 2

TABLE A-2 (Continued)

WIND SPEED (M/SEC) 3.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 4.713+03 | 7.951+02 | 3.475+02 | 2.015+02 | 1.131+02 | 8.337+00 | 2.687+00 | 3.007-01 | 8.936-02 | 3.902-02 | 1.601-02 | 9.966-04 |
| 300. | 9.427+02 | 1.590+02 | 6.951+01 | 4.030+01 | 2.261+01 | 1.667+00 | 5.425-01 | 9.150-02 | 3.988-02 | 2.250-02 | 1.149-02 | 9.472-04 |
| 900. | 3.142+02 | 5.300+01 | 2.317+01 | 1.343+01 | 7.538+00 | 5.558-01 | 1.808-01 | 3.050-02 | 1.333-02 | 7.730-03 | 4.338-03 | 6.679-04 |
| 3600. | 7.856+01 | 1.325+01 | 5.792+00 | 3.358+00 | 1.884+00 | 1.389-01 | 4.520-02 | 7.625-03 | 3.333-03 | 1.933-03 | 1.084-03 | 1.829-04 |
| 10800. | 2.619+01 | 4.417+00 | 1.931+00 | 1.119+00 | 6.282-01 | 4.632-02 | 1.507-02 | 2.542-03 | 1.111-03 | 6.442-04 | 3.615-04 | 6.097-05 |

MIXING HEIGHT (M) 4000.
STABILITY CLASS 2
WIND SPEED (M/SEC) 10.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.414+03 | 2.385+02 | 1.043+02 | 6.045+01 | 3.392+01 | 2.501+00 | 8.137-01 | 1.370-01 | 5.711-02 | 2.967-02 | 1.374-02 | 9.752-04 |
| 300. | 2.828+02 | 4.770+01 | 2.085+01 | 1.209+01 | 6.784+00 | 5.002-01 | 1.627-01 | 2.745-02 | 1.200-02 | 6.957-03 | 3.904-03 | 6.208-04 |
| 900. | 9.427+01 | 1.590+01 | 6.951+00 | 4.030+00 | 2.261+00 | 1.667-01 | 5.425-02 | 9.150-03 | 4.000-03 | 2.319-03 | 1.301-03 | 2.195-04 |
| 3600. | 2.357+01 | 3.975+00 | 1.738+00 | 1.008+00 | 5.653-01 | 4.168-02 | 1.356-02 | 2.288-03 | 9.999-04 | 5.798-04 | 3.253-04 | 5.487-05 |
| 10800. | 7.856+00 | 1.325+00 | 5.792-01 | 3.358-01 | 1.884-01 | 1.389-02 | 4.520-03 | 7.625-04 | 3.333-04 | 1.933-04 | 1.084-04 | 1.829-05 |

MIXING HEIGHT (M) 4000.
STABILITY CLASS 3
WIND SPEED (M/SEC) 1.0

| SMP. TIME (SEC) | DOWNWIND DISTANCE (KM) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
| 60. | 1.678+05 | 3.229+04 | 1.501+04 | 9.058+03 | 5.305+03 | 4.745+02 | 1.675+02 | 2.493+01 | 8.344+00 | 3.892+00 | 1.700+00 | 1.261-01 |
| 300. | 3.355+04 | 6.457+03 | 3.001+03 | 1.812+03 | 1.061+03 | 9.490+01 | 3.355+01 | 6.457+00 | 3.001+00 | 1.803+00 | 1.020+00 | 1.149-01 |
| 900. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 3600. | 2.796+03 | 5.381+02 | 2.501+02 | 1.510+02 | 8.842+01 | 7.908+00 | 2.796+00 | 5.381-01 | 2.501-01 | 1.510-01 | 8.842-02 | 1.702-02 |
| 10800. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.636+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |

MIXING HEIGHT (M) 4000.
STABILITY CLASS 3
WIND SPEED (M/SEC) 3.0

| SMP. | DOWNWIND DISTANCE (KM) |
|---|---|

TABLE A-2 (Continued)

| TIME (SEC) | 0.01 | 0.03 | 0.05 | 0.07 | 0.1 | 0.5 | 1.0 | 3.0 | 5.0 | 7.0 | 10.0 | 30.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60. | 5.592+04 | 1.076+04 | 5.002+03 | 3.019+03 | 1.768+03 | 1.582+02 | 5.592+01 | 1.076+01 | 4.894+00 | 2.752+00 | 1.388+00 | 1.222-01 |
| 300. | 1.118+04 | 2.152+03 | 1.000+03 | 6.039+02 | 3.537+02 | 3.163+01 | 1.118+01 | 2.152+00 | 1.000+00 | 6.039-01 | 3.537-01 | 6.672-02 |
| 900. | 3.728+03 | 7.175+02 | 3.335+02 | 2.013+02 | 1.179+02 | 1.054+01 | 3.728+00 | 7.175-01 | 3.335-01 | 2.013-01 | 1.179-01 | 2.269-02 |
| 3600. | 9.320+02 | 1.794+02 | 8.336+01 | 5.032+01 | 2.947+01 | 2.634+00 | 9.320-01 | 1.794-01 | 8.336-02 | 5.032-02 | 2.947-02 | 5.672-03 |
| 10800. | 3.107+02 | 5.979+01 | 2.779+01 | 1.677+01 | 9.824+00 | 8.787-01 | 3.107-01 | 5.979-02 | 2.779-02 | 1.677-02 | 9.824-03 | 1.891-03 |

TABLE A-2 (Continued)

STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0
MIXING HEIGHT (M) 1500.
SAMPLING TIME (SEC) 1.0

| DOWNWIND DISTANCE (KM) | DISTANCE FROM PUFF CENTER (M) | RECEPTOR HEIGHT (M) | CONCENTRATION (G/M**3) |
|---|---|---|---|
| 5.000 | .000 | .000 | 9.461-02 |

TABLE A-2 (Continued)

OPTION 1 NO
OPTION 2 YES
OPTION 3 NO

SOURCE INFORMATION

| | |
|---|---|
| SOURCE STRENGTH (G) | 1000000.0 |
| SOURCE HEIGHT (M) | .0 |
| INITIAL SIGMA R (M) | .0 |
| INITIAL SIGMA Z (M) | .0 |

METEOROLOGICAL DATA

| | |
|---|---|
| WIND SPEED (M/SEC) | 3.0 |
| MIXING HEIGHT (M) | 1500.0 |
| SAMPLING TIME (SEC) | 300.0 |
| STABILITY CLASS | 2 |

RECEPTOR DATA

| LOCATION NUMBER | DOWNWIND DISTANCE (KM) | RADIAL DISTANCE (M) | HEIGHT ABOVE GROUND (M) |
|---|---|---|---|
| 1 | 5.000 | .00 | .00 |

TABLE A-2 (Continued)

STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0
MIXING HEIGHT (M) 1500.
SAMPLING TIME (SEC) 300.0

| DOWNWIND DISTANCE (KM) | DISTANCE FROM PUFF CENTER (M) | RECEPTOR HEIGHT (M) | CONCENTRATION (G/M**3) |
|---|---|---|---|
| 5.000 | .000 | .000 | 3.988-02 |

TABLE A-2 (Continued)

OPTION 1 NO
OPTION 2 YES
OPTION 3 NO

SOURCE INFORMATION

| | |
|---|---|
| SOURCE STRENGTH (G) | 1000000.0 |
| SOURCE HEIGHT (M) | .0 |
| INITIAL SIGMA R (M) | .0 |
| INITIAL SIGMA Z (M) | .0 |

METEOROLOGICAL DATA

| | |
|---|---|
| WIND SPEED (M/SEC) | 3.0 |
| MIXING HEIGHT (M) | 1500.0 |
| SAMPLING TIME (SEC) | 3600.0 |
| STABILITY CLASS | 2 |

RECEPTOR DATA

| LOCATION NUMBER | DOWNWIND DISTANCE (KM) | RADIAL DISTANCE (M) | HEIGHT ABOVE GROUND (M) |
|---|---|---|---|
| 1 | 5.000 | .00 | .00 |

TABLE A-2 (Continued)

STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0
MIXING HEIGHT (M) 1500.
SAMPLING TIME (SEC) 3600.0

| DOWNWIND DISTANCE (KM) | DISTANCE FROM PUFF CENTER (M) | RECEPTOR HEIGHT (M) | CONCENTRATION (G/M**3) |
|---|---|---|---|
| 5.000 | .000 | .000 | 3.333-03 |

TABLE A-2 (Continued)

OPTION 1 NO
OPTION 2 YES
OPTION 3 YES

SOURCE INFORMATION

| | |
|---|---|
| SOURCE STRENGTH (G) | 1000000.0 |
| SOURCE HEIGHT (M) | 50.0 |
| INITIAL SIGMA R (M) | .0 |
| INITIAL SIGMA Z (M) | .0 |

METEOROLOGICAL DATA

| | |
|---|---|
| WIND SPEED (M/SEC) | 3.0 |
| MIXING HEIGHT (M) | 1500.0 |
| SAMPLING TIME (SEC) | 300.0 |
| STABILITY CLASS | 2 |

RECEPTOR DATA

| LOCATION NUMBER | DOWNWIND DISTANCE (KM) | RADIAL DISTANCE (M) | HEIGHT ABOVE GROUND (M) |
|---|---|---|---|
| 1 | 1.000 | .00 | .00 |
| 2 | 3.000 | .00 | .00 |
| 3 | 5.000 | .00 | .00 |

TABLE A-2 (Continued)

STABILITY CLASS 2
WIND SPEED (M/SEC) 3.0
MIXING HEIGHT (M) 1500.
SAMPLING TIME (SEC) 300.0

| DOWNWIND DISTANCE (KM) | DISTANCE FROM PUFF CENTER (M) | RECEPTOR HEIGHT (M) | CONCENTRATION (G/M**3) |
|---|---|---|---|
| 1.000 | .000 | .000 | 1.629-02 |
| 3.000 | .000 | .000 | 4.310-02 |
| 5.000 | .000 | .000 | 2.759-02 |

## TABLE A-2 (Continued)

| | |
|---|---|
| EMISSION STRENGTH (G) | 1000000.0 |
| EMISSION HEIGHT (M) | 50.0 |
| INITIAL SIGMA R (M) | .0 |
| INITIAL SIGMA Z (M) | .0 |
| WIND SPEED (M/SEC) | 3.0 |
| MIXING HEIGHT (M) | 1500.0 |
| STABILITY CLASS | 2 |
| SAMPLING TIME (SEC) | 300.0 |
| CRITICAL CONCENTRATION (G/M**3) | 1.000-04 |
| CRITICAL DOWNWIND DISTANCE (KM) | 73.687 |
| CONCENTRATION AT CONVERGENCE (G/M**3) | 1.000-04 |

ELEVATED RELEASE

| | |
|---|---|
| DISTANCE OUT TO PEAK CONCENTRATION (KM) | 2.207 |
| PEAK CONCENTRATION (G/M**3) | 4.730-02 |

APPENDIX B

SOURCE CODE LISTING

```
      DIMENSION HLID(4), SPD(6), XDIS(12), XR(100), RR(100), ZR(100), CH
     1IM(12), AVGT(5), YAN(2)
      DATA YAN /'YES',' NO'/
      DATA AVGT /60.,300.,900.,3600.,10800./
      DATA XDIS /.01,.03,.05,.07,.1,.5,1.,3.,5.,7.,10.,30./
      DATA HLID /500.,1000.,2000.,4000./
      DATA SPD /1.,3.,3.,10.,1.,3./
10    READ (5,330) KTL
      IF (KTL.GE.100) GO TO 320
C
C         KTL=1  NEW PROBLEM READ ALL INPUT DATA.
C         KTL=2  CHANGE THE OPTIONS ONLY.
C         KTL=3  CHANGE OPTIONS AND SOURCE DATA.
C         KTL=4  CHANGE OPTIONS AND METEOROLOGY.
C         KTL=5  CHANGE OPTIONS AND LOCATIONS OF CONCENTRATION
C                ESTIMATES.
C         KTL=6  CHANGE OPTIONS, METEOROLOGY, AND LOCATIONS OF
C                CONCENTRATION ESTIMATES.
C
      READ (5,330) IOUT1,IOUT2,IOUT3
C
C         IOUT1,IOUT2, AND IOUT3 ARE OUTPUT OPTIONS. A VALUE OF 1
C         INDICATES THE OPTION WILL BE EXECUTED.
C
C         IOUT1=1  TABLE OF CONCENTRATIONS FOR DIFFERENT STABILITY
C                   CLASSES, SAMPLING TIMES, AND DOWNWIND DISTANCES.
C         IOUT2=1  CONCENTRATION ESTIMATES FOR THE GIVEN INPUT DATA ONLY
C         IOUT3=1  A CRITICAL CONCENTRATION MUST BE INPUT. THE PROGRAM
C                   WILL COMPUTE DISTANCE TO CRITICAL CONCENTRATION.
C
      GO TO (20,50,20,30,40,30), KTL
C       READ SOURCE CARD
20    READ (5,330) Q,H,SYOP,SZOP
C
C   Q          SOURCE STRENGTH                          (G)
C   H          EFFECTIVE SOURCE HEIGHT                  (M)
C   SYOP       INITIAL SIGMA R                          (M)
C   SZOP       INITIAL SIGMA Z                          (M)
C
      GO TO (30,50,50,30,40,30), KTL
C       READ METEOROLOGY CARD
30    READ (5,330) U,HL,AVT,KST
C
C   U          WIND SPEED                               (M/SEC)
C   HL         MIXING HEIGHT                            (M)
C   AVT        SAMPLING TIME FOR CONCENTRATION
C              ESTIMATES                                (SEC)
C   KST        STABILITY CLASS     1-3
C
      GO TO (40,50,50,50,40,40), KTL
```

```
C       READ DOWNWIND DISTANCE, RADIAL DISTANCE FROM PUFF CENTER          00510
C       AND HEIGHT                                                        00520
40    READ (5,330) NREC,((XR(I),RR(I),ZR(I)),I=1,NREC)                   00530
C                                                                         00540
C     NREC       NUMBER OF LOCATIONS FOR WHICH CONCENTRATION             00550
C                ESTIMATES ARE MADE                                       00560
C     XR         DISTANCE DOWNWIND FROM RELEASE POINT    (KM)            00570
C     RR         RADIAL DISTANCE FROM PUFF CENTER        (M)             00580
C     ZR         HEIGHT ABOVE GROUND                     (M)             00590
C                                                                         00600
50    IF (IOUT3.EQ.1) READ (5,330) XCHI                                   00610
C                                                                         00620
C     XCHI       CRITICAL CONCENTRATION                  (G/M**3)        00630
C                                                                         00640
      IF (IOUT1.NE.1) IOUT1=2                                             00650
      IF (IOUT2.NE.1) IOUT2=2                                             00660
      IF (IOUT3.NE.1) IOUT3=2                                             00670
      WRITE (6,340) YAN(IOUT1),YAN(IOUT2),YAN(IOUT3)                      00680
      WRITE (6,350) Q,H,SYOP,SZOP                                         00690
      WRITE (6,360) U,HL,AVT,KST                                          00700
      WRITE (6,370)                                                       00710
      DO 60 I=1,NREC                                                      00720
      WRITE (6,380) I,XR(I),RR(I),ZR(I)                                   00730
60    CONTINUE                                                            00740
      CON1=2./(2.*3.14159)**1.5                                           00750
      CON2=1./(2.*3.14159)                                                00760
      CON3=1./(2.*3.14159)**1.5                                           00770
      IF (IOUT1.NE.1) GO TO 180                                           00780
      DO 100 ILID=1,4                                                     00790
      HLL=HLID(ILID)                                                      00800
      HLE=0.8*HLL                                                         00810
      WRITE (6,390) HLL                                                   00820
      DO 90 ISTA=1,3                                                      00830
      DO 80 IDIS=1,12                                                     00840
      XX=XDIS(IDIS)                                                       00850
      CALL PUFSIG (XX,ISTA,SR,SZ)                                         00860
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                            00870
      SR=SQRT(SR*SR+SYOP*SYOP)                                            00880
      E=EXP(-0.5*(H/SZ)**2)                                               00890
      CHIM(IDIS)=Q*E*CON1/(SR*SR*SZ)                                      00900
      IF (ISTA.EQ.3) GO TO 70                                             00910
      IF (SZ.GE.HLE) CHIM(IDIS)=Q*CON2/(SR*SR*HLL)                        00920
70    CONTINUE                                                            00930
80    CONTINUE                                                            00940
      WRITE (6,400) (ISTA,(CHIM(I),I=1,12))                               00950
90    CONTINUE                                                            00960
100   CONTINUE                                                            00970
      DO 170 ILID=1,4                                                     00980
      HLL=HLID(ILID)                                                      00990
      HLE=0.8*HLL                                                         01000
```

```
      DO 160 ISTA=1,3                                                    01010
      DO 150 IS=1,2                                                      01020
      ISN=(ISTA-1)*2+IS                                                  01030
      US=SPD(ISN)                                                        01040
      WRITE (6,410) HLL,ISTA,US                                          01050
      DO 140 IAVT=1,5                                                    01060
      AVG=AVGT(IAVT)                                                     01070
      DO 130 IDIS=1,12                                                   01080
      XX=XDIS(IDIS)                                                      01090
      CALL PUFSIG (XX,ISTA,SR,SZ)                                        01100
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                           01110
      SR=SQRT(SR*SR+SYOP*SYOP)                                           01120
      E=EXP(-0.5*(H/SZ)**2)                                              01130
      CHIMAX=Q*E*CON1/(SR*SR*SZ)                                         01140
      IF (ISTA.EQ.3) GO TO 110                                           01150
      IF (SZ.GE.HLE) CHIMAX=Q*CON2/(SR*SR*HLL)                           01160
  110 CONTINUE                                                           01170
      AVGC=1.                                                            01180
      IF (AVG.LT.1.) GO TO 120                                           01190
      SGWT=AVG*US/(SR*2.)                                                01200
      CALL AVCOR (SGWT,AVGC)                                             01210
  120 CHIM(IDIS)=CHIMAX*AVGC                                             01220
  130 CONTINUE                                                           01230
      WRITE (6,420) (AVG,(CHIM(I),I=1,12))                               01240
  140 CONTINUE                                                           01250
  150 CONTINUE                                                           01260
  160 CONTINUE                                                           01270
  170 CONTINUE                                                           01280
  180 CONTINUE                                                           01290
      IF (IOUT2.NE.1) GO TO 230                                          01300
      WRITE (6,430) KST,U,HL,AVT                                         01310
      HLE=0.8*HL                                                         01320
      DO 220 IR=1,NREC                                                   01330
      XX=XR(IR)                                                          01340
      CALL PUFSIG (XX,KST,SR,SZ)                                         01350
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                           01360
      SR=SQRT(SR*SR+SYOP*SYOP)                                           01370
      IF (SZ.GE.HLE.AND.KST.LE.2) GO TO 190                              01380
      E1=-0.5*(RR(IR)/SR)**2                                             01390
      E2=-0.5*(((ZR(IR)+H)/SZ)**2)                                       01400
      E3=-0.5*(((ZR(IR)-H)/SZ)**2)                                       01410
      CHI=(Q*CON3/(SZ*SR*SR))*(EXP(E1)*(EXP(E2)+EXP(E3)))                01420
      GO TO 200                                                          01430
  190 CONTINUE                                                           01440
      E1=EXP(-0.5*(RR(IR)/SR)**2)                                        01450
      CHI=(Q*CON2/(SR**2*HL))*E1                                         01460
  200 CONTINUE                                                           01470
      IF (AVT.LT.1.) GO TO 210                                           01480
      SGWT=AVT*U/(SR*2.)                                                 01490
      CALL AVCOR (SGWT,AVGC)                                             01500
```

```
      CHI=CHI*AVGC                                                          01510
      WRITE (6,440) XR(IR),RR(IR),ZR(IR),CHI                                01520
210   CONTINUE                                                              01530
220   CONTINUE                                                              01540
230   IF (IOUT3.NE.1) GO TO 310                                             01550
      CL=0.                                                                 01560
      XPK=0.                                                                01570
      IF (H.GT.1.) CALL DBTMX (Q,KST,H,U,AVT,SYOP,SZOP,XPK,CL)              01580
      IF (H.GT.1..AND.XCHI.GT.CL) GO TO 300                                 01590
      X=0.                                                                  01600
      HLE=0.8*HL                                                            01610
      KD=9                                                                  01620
      DO 280 K=1,KD                                                         01630
      DX=10.**(KD-K)                                                        01640
      DO 260 J=1,10                                                         01650
      X=X+DX                                                                01660
      XI=X/10000.                                                           01670
      IF (XI.LT.XPK) XI=XPK                                                 01680
      XX=XI                                                                 01690
      CALL PUFSIG (XX,KST,SR,SZ)                                            01700
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                              01710
      SR=SQRT(SR*SR+SYOP*SYOP)                                              01720
      E=EXP(-0.5*(H/SZ)**2)                                                 01730
      CHI=(Q*CON1/(SR**2*SZ))*E                                             01740
      IF (KST.EQ.3) GO TO 240                                               01750
      IF (SZ.GE.HLE) CHI=Q*CON2/(SR**2*HL)                                  01760
240   CONTINUE                                                              01770
      IF (AVT.LT.1.) GO TO 250                                              01780
      SGWT=AVT*U/(SR*2.)                                                    01790
      CALL AVCOR (SGWT,AVGC)                                                01800
      CHI=CHI*AVGC                                                          01810
250   DIFF=XCHI-CHI                                                         01820
      IF (DIFF) 260,290,270                                                 01830
260   CONTINUE                                                              01840
270   X=X-DX                                                                01850
280   CONTINUE                                                              01860
290   CONTINUE                                                              01870
      WRITE (6,450) Q,H,SYOP,SZOP,U,HL,KST,AVT,XCHI                         01880
      WRITE (6,460) XI,CHI                                                  01890
      IF (H.GT.1.) WRITE (6,470) XPK,CL                                     01900
      GO TO 210                                                             01910
300   CONTINUE                                                              01920
      WRITE (6,480) XPK,XCHI,CL                                             01930
310   CONTINUE                                                              01940
      GO TO 10                                                              01950
320   STOP                                                                  01960
C                                                                           01970
330   FORMAT ()                                                             01980
340   FORMAT ('1',8X,'OPTION 1',5X,A3,/,9X,'OPTION 2',5X,A3,/,9X,'OPTION    01990
     1 3',5X,A3,///)                                                        02000
```

```
350   FORMAT (15X,'SOURCE INFORMATION',//,5X,'SOURCE STRENGTH (G)',T30,F   02010
     110.1,/,5X,'SOURCE HEIGHT (M)',T30,F6.1,/,5X,'INITIAL SIGMA R (M)',  02020
     2T30,F6.1,/,5X,'INITIAL SIGMA Z (M)',T30,F6.1,///)                   02030
360   FORMAT (15X,'METEOROLOGICAL DATA',//,5X,'WIND SPEED (M/SEC)',T30,F   02040
     14.1,/,5X,'MIXING HEIGHT (M)',T30,F6.1,/,5X,'SAMPLING TIME (SEC)',T  02050
     228,F7.1,/,5X,'STABILITY CLASS',T33,I1,///)                          02060
370   FORMAT (T16,'RECEPTOR DATA',/,T5,'LOCATION',T20,'DOWNWIND',T35,'RA   02070
     1DIAL',T50,'HEIGHT ABOVE',/,T6,'NUMBER',T20,'DISTANCE',T35,'DISTANC  02080
     2E',T54,'GROUND',/,T23,'(KM)',T37,'(M)',T56,'(M)',/)                 02090
                                                                          02100
380   FORMAT (T7,I3,T20,F8.3,T33,F8.2,T52,F8.2)                            02110
390   FORMAT (//////,5X,'MIXING HEIGHT (M)',2X,F6.0,/,1X'STAB.',T40,'DOW   02120
     1NWIND DISTANCE  (KM)',/,1X,'CLAS',/,T8,'0.01',T18,'0.03',T28,'0.05  02130
     2',T38,'0.07',T49,'0.1',T59,'0.5',T69,'1.0',T79,'3.0',T89,'5.0',T99  02140
     3,'7.0',T108,'10.0',T118,'30.0',//)                                  02150
400   FORMAT (2X,I1,3X,1P12(E9.3,1X))                                      02160
410   FORMAT (////,1X,'MIXING HEIGHT (M)',2X,F5.0,/,1X,'STABILITY CLASS'   02170
     1,2X,I1,/,1X,'WIND SPEED (M/SEC)',2X,F5.1,//,4X,'SMP.',T40,'DOWNWIN  02180
     2D DISTANCE (KM)',/,4X,'TIME (SEC)',/,T13,'0.01',T23,'0.03',T33,'0.  02190
     305',T43,'0.07',T54,'0.1',T64,'0.5',T74,'1.0',T84,'3.0',T94,'5.0',T  02200
     4104,'7.0',T113,'10.0',T123,'30.0',//)                               02210
420   FORMAT (2X,F7.0,2X,1P12(E9.3,1X))                                    02220
430   FORMAT ('1',4X,'STABILITY CLASS',2X,I1,/,5X,'WIND SPEED (M/SEC)',2   02230
     1X,F5.1,/,5X,'MIXING HEIGHT (M)',2X,F5.0,/,5X,'SAMPLING TIME (SEC)'  02240
     2,2X,F7.1,//,1X,'DOWNWIND',T14,'DISTANCE FROM',T31,'RECEPTOR',T47,'  02250
     3CONCENTRATION',/,1X,'DISTANCE',T15,'PUFF CENTER',T32,'HEIGHT',T50,  02260
     4'(G/M**3)',/,3X,'(KM)',T18,'(M)',T33,'(M)',/)                       02270
440   FORMAT (1X,F8.3,T14,F8.3,T31,F8.3,T48,1PE9.3)                        02280
450   FORMAT ('1',4X,'EMISSION STRENGTH (G)',T35,F10.1,/,5X,'EMISSION HE   02290
     1IGHT (M)',T35,F6.1,/,5X,'INITIAL SIGMA R (M)',T35,F5.1,/,5X,'INITI  02300
     2AL SIGMA Z (M)',T35,F5.1,/,5X,'WIND SPEED (M/SEC)',T35,F5.1,/,5X,'  02310
     3MIXING HEIGHT (M)',T35,F6.1,/,5X,'STABILITY CLASS  ',T35,I1,/,5X,'  02320
     4SAMPLING TIME (SEC) ',T35,F7.1,/,5X,'CRITICAL CONCENTRATION',' (G/  02330
     5M**3)',T45,1PE9.3,/)                                                02340
460   FORMAT (5X,'CRITICAL DOWNWIND DISTANCE (KM) ',T45,F9.3,/,5X,'CONCE   02350
     1NTRATION AT CONVERGENCE (G/M**3) ',T45,1PE9.3,////////)              02360
470   FORMAT (///,5X,'ELEVATED RELEASE',/,5X,'DISTANCE OUT TO PEAK CONCE   02370
     1NTRATION (KM) ',F8.3,/,5X,'PEAK CONCENTRATION (G/M**3) ',1PE9.3)    02380
480   FORMAT ('1',5X,'CRITICAL CONCENTRATION IS GREATER ','THAN PEAK CON   02390
     1CENTRATION',/,5X,'DISTANCE OUT TO PEAK CONCENTRATION (KM) ',F8.3,/  02400
     2,5X,'CRITICAL CONCENTRATION (G/M**3) ',1PE9.3,/,5X,'PEAK CONCENTRA  02410
     3TION (G/M**3) ',1PE9.3)                                             02420
C                                                                         02430
      END


      SUBROUTINE PUFSIG (X,KST,SR,SZ)                                     00010
      DIMENSION AY(3), AZ(3), BY(3), BZ(3)                                00020
      DATA AY /0.14,0.06,0.02/                                            00030
      DATA AZ /0.53,0.15,0.05/                                            00040
```

```
      DATA BY /0.92,0.92,0.89/                                          00050
      DATA BZ /0.73,0.70,0.61/                                          00060
C                                                                       00070
C       PUFSIG COMPUTES SIGMA R AND SIGMA Z, USING THE CURVES           00080
C       RECOMMENDED IN METEOROLOGY AND ATOMIC ENERGY (1968) P. 175      00090
C                                                                       00100
C         X       DOWNWIND DISTANCE                       (KM)          00110
C         KST     STABILITY CLASS                                       00120
C         SR      SIGMA R                                 (M)           00130
C         SZ      SIGMA Z                                 (M)           00140
C                                                                       00150
      XK=1000.*X                                                        00160
      GO TO (10,20,30), KST                                             00170
10    SR=AY(1)*XK**BY(1)                                                00180
      SZ=AZ(1)*XK**BZ(1)                                                00190
      RETURN                                                            00200
20    SR=AY(2)*XK**BY(2)                                                00210
      SZ=AZ(2)*XK**BZ(2)                                                00220
      RETURN                                                            00230
30    SR=AY(3)*XK**BY(3)                                                00240
      SZ=AZ(3)*XK**BZ(3)                                                00250
      RETURN                                                            00260
C                                                                       00270
      END                                                               00280


      SUBROUTINE AVCOR(SGWT,AVGC)                                       00010
C                                                                       00020
C      AVCOR COMPUTES AREA UNDER NORMAL CURVE.                          00030
C                                                                       00040
C      SGWT       NUMBER OF STANDARD DEVIATIONS                        00050
C      AVGC       AREA UNDER NORMAL CURVE                              00060
C                                                                       00070
      R=0.2316419                                                       00080
      B1=0.319381530                                                    00090
      B2=-0.356563782                                                   00100
      B3=1.781477937                                                    00110
      B4=-1.821255978                                                   00120
      B5=1.330274429                                                    00130
      C=1./SQRT(2.*3.14159)                                             00140
      X=SGWT                                                            00150
C       X IS THE NUMBER OF STANDARD DEVIATIONS ABOUT THE MEAN           00160
      E=EXP(-(X**2/2.))                                                 00170
      T=1./(1.+R*X)                                                     00180
      RR=C*E*(B1*T+B2*T**2+B3*T**3+B4*T**4+B5*T**5)                     00190
      A=1.-RR                                                           00200
      AVGC=2.*(A-0.5)/(2.*X*0.398942)                                   00210
      RETURN                                                            00220
      END                                                               00230
```

```
      SUBROUTINE DBTMX (Q,KST,H,U,AVT,SYOP,SZOP,XL,CL)                  00010
C                                                                       00020
C       DBTMX COMPUTES DISTANCE TO MAXIMUM CONCENTRATION.               00030
C                                                                       00040
C     Q         SOURCE STRENGTH                              (G)        00050
C     KST       STABILITY CLASS                                         00060
C     H         EFFECTIVE PUFF HEIGHT                        (M)        00070
C     U         WIND SPEED                                   (M/SEC)    00080
C     AVT       SAMPLING TIME                                (SEC)      00090
C     SYOP      INITIAL HORIZONTAL DISPERSION                (M)        00100
C     SZOP      INITIAL VERTICAL DISPERSION                  (M)        00110
C     XL        DISTANCE TO MAXIMUM CONCENTRATION            (KM)       00120
C     CL        MAXIMUM CONCENTRATION                        (G/M**3)   00130
C                                                                       00140
      CON1=2./(2.*3.14159)**1.5                                         00150
      IA=1                                                              00160
      XL=0.0                                                            00170
      RC=0.0                                                            00180
      X=0.01                                                            00190
      DX=0.01                                                           00200
10    CL=RC                                                             00210
      XX=X                                                              00220
      CALL PUFSIG (XX,KST,SR,SZ)                                        00230
      SR=SQRT(SR*SR+SYOP*SYOP)                                          00240
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                          00250
      E=EXP(-0.5*(H/SZ)**2)                                             00260
      RC=(Q*CON1/(SR**2*SZ))*E                                          00270
      IF (AVT.LT.1.) GO TO 20                                           00280
      SGWT=AVT*U/(SR*2.)                                                00290
      CALL AVCOR (SGWT,AVGC)                                            00300
      RC=RC*AVGC                                                        00310
20    IF (RC-CL) 110,30,30                                              00320
30    XL=X                                                              00330
      X=X+DX                                                            00340
      GO TO (40,60,80,100), IA                                          00350
40    IF (X-0.192) 10,10,50                                             00360
50    IA=2                                                              00370
      X=0.2                                                             00380
      DX=0.1                                                            00390
      GO TO 10                                                          00400
60    IF (X-3.92) 10,10,70                                              00410
70    IA=3                                                              00420
      X=4.0                                                             00430
      DX=1.0                                                            00440
      GO TO 10                                                          00450
80    IF (X-19.2) 10,10,90                                              00460
90    IA=4                                                              00470
```

```
      X=20.0                                                            00480
      DX=10.0                                                           00490
      GO TO 10                                                          00500
  100 IF (X-305.0) 10,10,200                                            00510
  110 IF (DX-0.001) 120,120,130                                         00520
  120 RETURN                                                            00530
  130 DX=0.1*DX                                                         00540
  140 XL=X                                                              00550
      X=X-DX                                                            00560
      CL=RC                                                             00570
      XX=X                                                              00580
      CALL PUFSIG (XX,KST,SR,SZ)                                        00590
      SR=SQRT(SR*SR+SYOP*SYOP)                                          00600
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                          00610
      E=EXP(-0.5*(H/SZ)**2)                                             00620
      RC=(Q*CON1/(SR**2*SZ))*E                                          00630
      IF (AVT.LT.1.) GO TO 150                                          00640
      SGWT=AVT*U/(SR*2.)                                                00650
      CALL AVCOR (SGWT,AVGC)                                            00660
      RC=RC*AVGC                                                        00670
  150 IF (RC-CL) 160,140,140                                            00680
  160 IF (DX-0.001) 120,120,170                                         00690
  170 DX=0.1*DX                                                         00700
  180 XL=X                                                              00710
      X=X+DX                                                            00720
      CL=RC                                                             00730
      XX=X                                                              00740
      CALL PUFSIG (XX,KST,SR,SZ)                                        00750
      SR=SQRT(SR*SR+SYOP*SYOP)                                          00760
      SZ=SQRT(SZ*SZ+SZOP*SZOP)                                          00770
      E=EXP(-0.5*(H/SZ)**2)                                             00780
      RC=(Q*CON1/(SR**2*SZ))*E                                          00790
      SGWT=AVT*U/(SR*2.)                                                00800
      CALL AVCOR (SGWT,AVGC)                                            00810
      RC=RC*AVGC                                                        00820
      IF (RC-CL) 190,180,180                                            00830
  190 IF (DX-0.001) 120,120,130                                         00840
  200 XL=999.0                                                          00850
      CL=99.0                                                           00860
      RETURN                                                            00870
C                                                                       00880
      END                                                               00890
```

## APPENDIX C
## CHANGES TO THE DISPERSION PARAMETERS

The horizontal and vertical dispersion parameters in the instantaneous puff model are of the form $ax^b$. The constants a and b are in data statements in Subroutine PUFSIG and can be easily changed. If more than three stability classes are desired, additional modifications to the code are required besides those given here. The constants a and b for the horizontal dispersion parameters are contained in arrays AY and BY respectively. Likewise the constants for the vertical dispersion parameters are in arrays AZ and BZ. Listed below are the DATA statements that contain the values of the constants a and b.

| | UNSTABLE | NEUTRAL | VERY STABLE |
|---|---|---|---|
| DATA AY | 0.14 | 0.06 | 0.02 |
| DATA AZ | 0.53 | 0.15 | 0.05 |
| DATA BY | 0.92 | 0.92 | 0.89 |
| DATA BZ | 0.73 | 0.70 | 0.61 |

To change the dispersion for the three stability classes change the values in the DATA statements in PUFSIG.

## APPENDIX D
## PUFF MODEL ON PROGRAMMABLE CALCULATOR

The instantaneous puff model has been programmed on the HP-67 programmable calculator. In programming the puff model, two magnetic recording cards will be required. The dispersion algorithm is stored on the first card, and the code necessary to compute average concentrations over some sampling time is stored on the second card. The dispersion model can be executed without utilizing the second magnetic card, so that estimates of the peak concentration can be made using only the first magnetic card.

Table D-1 provides the program steps necessary to generate the two programs. Table D-2 shows the storage locations for the input parameters. To execute the dispersion model after the program has been stored in program memory and the input parameters have been stored in their appropriate registers enter the downwind distance in (km) and press "A". The calculator will show the concentration in ($gm^{-3}$). To perform another calculation for another downwind distance, simply enter the distance and press "A". This process can be repeated for as many downwind distances as you require.

If average concentrations are needed, the second card must be read in after the completion of the dispersion algorithm. This routine uses information generated by the dispersion routine. In addition, the wind speed must be stored in register 2 and the sampling time stored in register 3. After this information has been stored, press "A" to execute the program.

To calculate concentrations for different sampling times, store the sampling time in register 3 and press "A". This can be done for as many sampling times as needed. This process could be repeated for different wind speeds as well.

To demonstrate the use of the model run the dispersion program for example problem 3-1 (A).

Steps

1. Read magnetic card with dispersion model.
2. Store stability (1) in sti.
3. Store source height (0) in register 6.
4. Store $\sigma_{y_o}$ and $\sigma_{z_o}(9.3)$ in register 7 and 8, respectively.
5. Store Q ($1.5 \times 10^4$) in register 9.
6. Store mixing height (1500) in register E.
7. Enter 10.
8. Press A.

$$\chi_p = 9.619 \times 10^{-6} \text{ g/m}^3$$

What is the 1-hour average concentration at this downwind distance.

Steps

1. Store wind speed (3) in register 2.
2. Store averaging time (3600) in register 3.
3. Read magnetic card with sampling time routine.
4. Press "A".

$$\chi = 1.496 \times 10^{-6} \text{ g/m}^3$$

TABLE D-1 HP-67 PROGRAM STEPS FOR PUFF MODEL

CARD ONE

| | | | |
|---|---|---|---|
| 001 | *LBLA | 21 11 | |
| 002 | STOI | 33 01 | |
| 003 | RCL9 | 36 09 | |
| 004 | 2 | 02 | |
| 005 | × | -35 | |
| 006 | STO0 | 35 00 | |
| 007 | 2 | 02 | |
| 008 | Pi | 16-24 | |
| 009 | × | -35 | |
| 010 | 1 | 01 | |
| 011 | . | -62 | |
| 012 | 5 | 05 | |
| 013 | $Y^x$ | 31 | |
| 014 | 1/X | 52 | |
| 015 | RCL0 | 36 00 | |
| 016 | × | -35 | |
| 017 | STO0 | 35 00 | |
| 018 | GSBC | 23 13 | |
| 019 | RCL4 | 36 04 | |
| 020 | $X^2$ | 53 | |
| 021 | RCL7 | 36 07 | |
| 022 | $X^2$ | 53 | |
| 023 | + | -55 | |
| 024 | STOA | 35 11 | |
| 025 | RCL5 | 36 05 | |
| 026 | $X^2$ | 53 | |
| 027 | RCL8 | 36 08 | |
| 028 | $X^2$ | 53 | |
| 029 | + | -55 | |
| 030 | $\sqrt{X}$ | 54 | |
| 031 | STOB | 35 12 | |
| 032 | RCLA | 36 11 | |
| 033 | × | -35 | |
| 034 | 1/X | 52 | |
| 035 | RCL0 | 36 00 | |
| 036 | × | -35 | |
| 037 | STO0 | 35 00 | |
| 038 | RCL6 | 36 06 | |
| 039 | RCLB | 36 12 | |
| 040 | ÷ | -24 | |
| 041 | $X^2$ | 53 | |
| 042 | . | -62 | |
| 043 | 5 | 05 | |
| 044 | CHS | -22 | |
| 045 | × | -35 | |
| 046 | $e^x$ | 33 | |
| 047 | RCL0 | 36 00 | |
| 048 | × | -35 | |
| 049 | DSP3 | -63 03 | 1 |
| 050 | SCI | -12 | |
| 051 | STO0 | 35 00 | |
| 052 | RCLE | 36 15 | |
| 053 | . | -62 | |
| 054 | 8 | 08 | |
| 055 | × | -35 | |
| 056 | RCLB | 36 12 | |
| 057 | X>Y? | 16-34 | |
| 058 | GTOD | 22 14 | |
| 059 | RCL0 | 36 00 | |
| 060 | RTN | 24 | |
| 061 | *LBLD | 21 14 | |
| 062 | RCLA | 36 11 | |
| 063 | RCLE | 36 15 | |
| 064 | × | -35 | |
| 065 | Pi | 16-24 | |
| 066 | × | -35 | |
| 067 | 2 | 02 | |
| 068 | × | -35 | |
| 069 | 1/X | 52 | |
| 070 | RCL9 | 36 09 | |
| 071 | × | -35 | |
| 072 | STO0 | 35 00 | |
| 073 | RTN | 24 | |
| 074 | *LBLC | 21 13 | |
| 075 | RCL1 | 36 01 | |
| 076 | 1 | 01 | |
| 077 | 0 | 00 | |
| 078 | 0 | 00 | |
| 079 | 0 | 00 | |
| 080 | STx1 | 35-35 01 | |
| 081 | GTOi | 22 45 | |
| 082 | *LBL1 | 21 01 | |
| 083 | . | -62 | |
| 084 | 9 | 09 | |
| 085 | 2 | 02 | |
| 086 | STOA | 35 11 | |
| 087 | . | -62 | |
| 088 | 1 | 01 | |
| 089 | 4 | 04 | |
| 090 | STOB | 35 12 | |
| 091 | . | -62 | |
| 092 | 7 | 07 | |
| 093 | 3 | 03 | |
| 094 | STOC | 35 13 | |
| 095 | . | -62 | |
| 096 | 5 | 05 | |
| 097 | 3 | 03 | |
| 098 | STOD | 35 14 | |
| 099 | RCL1 | 36 01 | |
| 100 | RCLA | 36 11 | |
| 101 | $Y^x$ | 31 | |
| 102 | RCLB | 36 12 | |
| 103 | × | -35 | |
| 104 | STO4 | 35 04 | |
| 105 | RCL1 | 36 01 | |



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TABLE D-1 (Continued)

CARD ONE

| | | |
|---|---|---|
| 105 | RCLC | 36 13 |
| 107 | Y^x | 31 |
| 108 | RCLD | 36 14 |
| 109 | × | -35 |
| 110 | STO5 | 35 05 |
| 111 | RTN | 24 |
| 112 | *LBL2 | 21 02 |
| 113 | . | -62 |
| 114 | 9 | 09 |
| 115 | 2 | 02 |
| 116 | STOA | 35 11 |
| 117 | . | -62 |
| 118 | 0 | 00 |
| 119 | 6 | 06 |
| 120 | STOB | 35 12 |
| 121 | . | -62 |
| 122 | 7 | 07 |
| 123 | STOC | 35 13 |
| 124 | . | -62 |
| 125 | 1 | 01 |
| 126 | 5 | 05 |
| 127 | STOD | 35 14 |
| 128 | RCL1 | 36 01 |
| 129 | RCLA | 36 11 |
| 130 | Y^x | 31 |
| 131 | RCLB | 36 12 |
| 132 | × | -35 |
| 133 | STO4 | 35 04 |
| 134 | RCL1 | 36 01 |
| 135 | RCLC | 36 13 |
| 136 | Y^x | 31 |
| 137 | RCLD | 36 14 |
| 138 | × | -35 |
| 139 | STO5 | 35 05 |
| 140 | RTN | 24 |
| 141 | *LBL3 | 21 03 |
| 142 | . | -62 |
| 143 | 8 | 08 |
| 144 | 9 | 09 |
| 145 | STOA | 35 11 |
| 146 | . | -62 |
| 147 | 0 | 00 |
| 148 | 2 | 02 |
| 149 | STOB | 35 12 |
| 150 | . | -62 |
| 151 | 6 | 06 |
| 152 | 1 | 01 |
| 153 | STOC | 35 13 |
| 154 | . | -62 |
| 155 | 0 | 00 |
| 156 | 5 | 05 |
| 157 | STOD | 35 14 |
| 158 | RCL1 | 36 01 |
| 159 | RCLA | 36 11 |
| 160 | Y^x | 31 |
| 161 | RCLB | 36 12 |
| 162 | × | -35 |
| 163 | STO4 | 35 04 |
| 164 | RCL1 | 36 01 |
| 165 | RCLC | 36 13 |
| 166 | Y^x | 31 |
| 167 | RCLD | 36 14 |
| 168 | × | -35 |
| 169 | STO5 | 35 05 |
| 170 | RTN | 24 |
| 171 | R/S | 51 |

TABLE D-1 (Continued)

CARD TWO

| | | |
|---|---|---|
| 001 | *LBLA | 21 11 |
| 002 | RCL4 | 36 04 |
| 003 | 2 | 02 |
| 004 | × | -35 |
| 005 | 1/X | 52 |
| 006 | RCL2 | 36 02 |
| 007 | × | -35 |
| 008 | RCL3 | 36 03 |
| 009 | × | -35 |
| 010 | STOA | 35 11 |
| 011 | 2 | 02 |
| 012 | Pi | 16-24 |
| 013 | × | -35 |
| 014 | √X | 54 |
| 015 | 1/X | 52 |
| 016 | STOC | 35 13 |
| 017 | RCLA | 36 11 |
| 018 | $X^2$ | 53 |
| 019 | 2 | 02 |
| 020 | ÷ | -24 |
| 021 | CHS | -22 |
| 022 | $e^x$ | 33 |
| 023 | STOD | 35 14 |
| 024 | RCLA | 36 11 |
| 025 | . | -62 |
| 026 | 2 | 02 |
| 027 | 3 | 03 |
| 028 | 1 | 01 |
| 029 | 6 | 06 |
| 030 | 4 | 04 |
| 031 | 1 | 01 |
| 032 | 9 | 09 |
| 033 | × | -35 |
| 034 | 1 | 01 |
| 035 | + | -55 |
| 036 | 1/X | 52 |
| 037 | STO1 | 35 01 |
| 038 | 5 | 05 |
| 039 | $Y^x$ | 31 |
| 040 | 1 | 01 |
| 041 | . | -62 |
| 042 | 3 | 03 |
| 043 | 3 | 03 |
| 044 | 0 | 00 |
| 045 | 2 | 02 |
| 046 | 7 | 07 |
| 047 | 4 | 04 |
| 048 | 4 | 04 |
| 049 | 2 | 02 |
| 050 | 9 | 09 |
| 051 | × | -35 |
| 052 | RCL1 | 36 01 |
| 053 | 4 | 04 |
| 054 | $Y^x$ | 31 |
| 055 | 1 | 01 |
| 056 | . | -62 |
| 057 | 8 | 08 |
| 058 | 2 | 02 |
| 059 | 1 | 01 |
| 060 | 2 | 02 |
| 061 | 5 | 05 |
| 062 | 9 | 09 |
| 063 | 7 | 07 |
| 064 | 8 | 08 |
| 065 | CHS | -22 |
| 066 | × | -35 |
| 067 | + | -55 |
| 068 | RCL1 | 36 01 |
| 069 | 3 | 03 |
| 070 | $Y^x$ | 31 |
| 071 | 1 | 01 |
| 072 | . | -62 |
| 073 | 7 | 07 |
| 074 | 8 | 08 |
| 075 | 1 | 01 |
| 076 | 4 | 04 |
| 077 | 7 | 07 |
| 078 | 7 | 07 |
| 079 | 9 | 09 |
| 080 | 3 | 03 |
| 081 | 7 | 07 |
| 082 | × | -35 |
| 083 | + | -55 |
| 084 | RCL1 | 36 01 |
| 085 | $X^2$ | 53 |
| 086 | . | -62 |
| 087 | 3 | 03 |
| 088 | 5 | 05 |
| 089 | 6 | 06 |
| 090 | 5 | 05 |
| 091 | 6 | 06 |
| 092 | 3 | 03 |
| 093 | 7 | 07 |
| 094 | 8 | 08 |
| 095 | 2 | 02 |
| 096 | CHS | -22 |
| 097 | × | -35 |
| 098 | + | -55 |
| 099 | RCL1 | 36 01 |
| 100 | . | -62 |
| 101 | 3 | 03 |
| 102 | 1 | 01 |
| 103 | 9 | 09 |
| 104 | 3 | 03 |

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TABLE D-1 (Continued)

CARD TWO

| | | |
|---|---|---|
| 105 | 8 | 08 |
| 106 | 1 | 01 |
| 107 | 5 | 05 |
| 108 | 3 | 03 |
| 109 | × | -35 |
| 110 | + | -55 |
| 111 | RCLD | 36 14 |
| 112 | × | -35 |
| 113 | RCLC | 36 13 |
| 114 | × | -35 |
| 115 | CHS | -22 |
| 116 | 1 | 01 |
| 117 | + | -55 |
| 118 | . | -62 |
| 119 | 5 | 05 |
| 120 | - | -45 |
| 121 | 2 | 02 |
| 122 | × | -35 |
| 123 | STO1 | 35 01 |
| 124 | RCLA | 36 11 |
| 125 | . | -62 |
| 126 | 3 | 03 |
| 127 | 9 | 09 |
| 128 | 8 | 08 |
| 129 | 9 | 09 |
| 130 | 4 | 04 |
| 131 | 2 | 02 |
| 132 | × | -35 |
| 133 | 2 | 02 |
| 134 | × | -35 |
| 135 | 1/X | 52 |
| 136 | RCL1 | 36 01 |
| 137 | × | -35 |
| 138 | RCL0 | 36 00 |
| 139 | × | -35 |
| 140 | STO1 | 35 01 |
| 141 | DSP3 | -63 03 |
| 142 | SCI | -12 |
| 143 | RCL0 | 36 00 |
| 144 | RCL1 | 36 01 |
| 145 | X>Y? | 16-34 |
| 146 | GTOD | 22 14 |
| 147 | RTN | 24 |
| 148 | *LBLD | 21 14 |
| 149 | RCL0 | 36 00 |
| 150 | RTN | 24 |
| 151 | R/S | 51 |

TABLE D-2 STORAGE LOCATIONS FOR INPUT PARAMETERS

| INPUT | REGISTER |
|---|---|
| Stability Class | sti |
| Source Height | 6 |
| Initial Sigma Y | 7 |
| Initial Sigma Z | 8 |
| Source Strength | 9 |
| Mixing Height | E |
| | |
| FOR CARD TWO | |
| | |
| Wind Speed | 2 |
| Sampling Time | 3 |